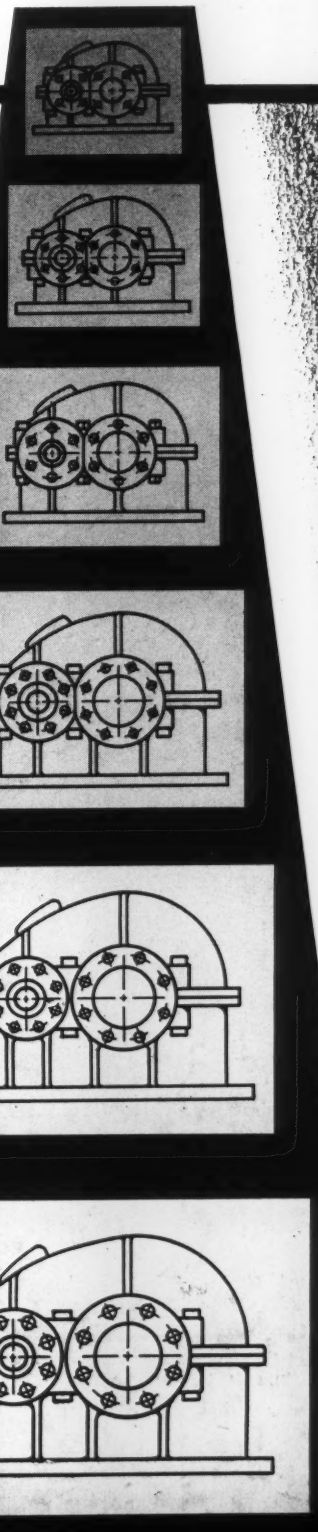
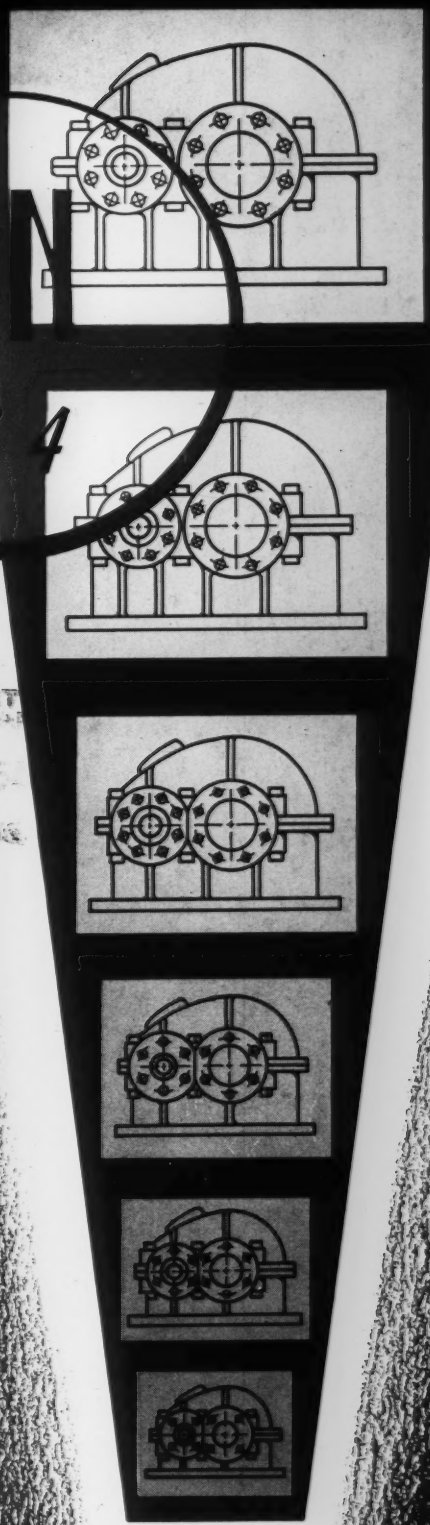
MACHINE DESIGN

July 1954





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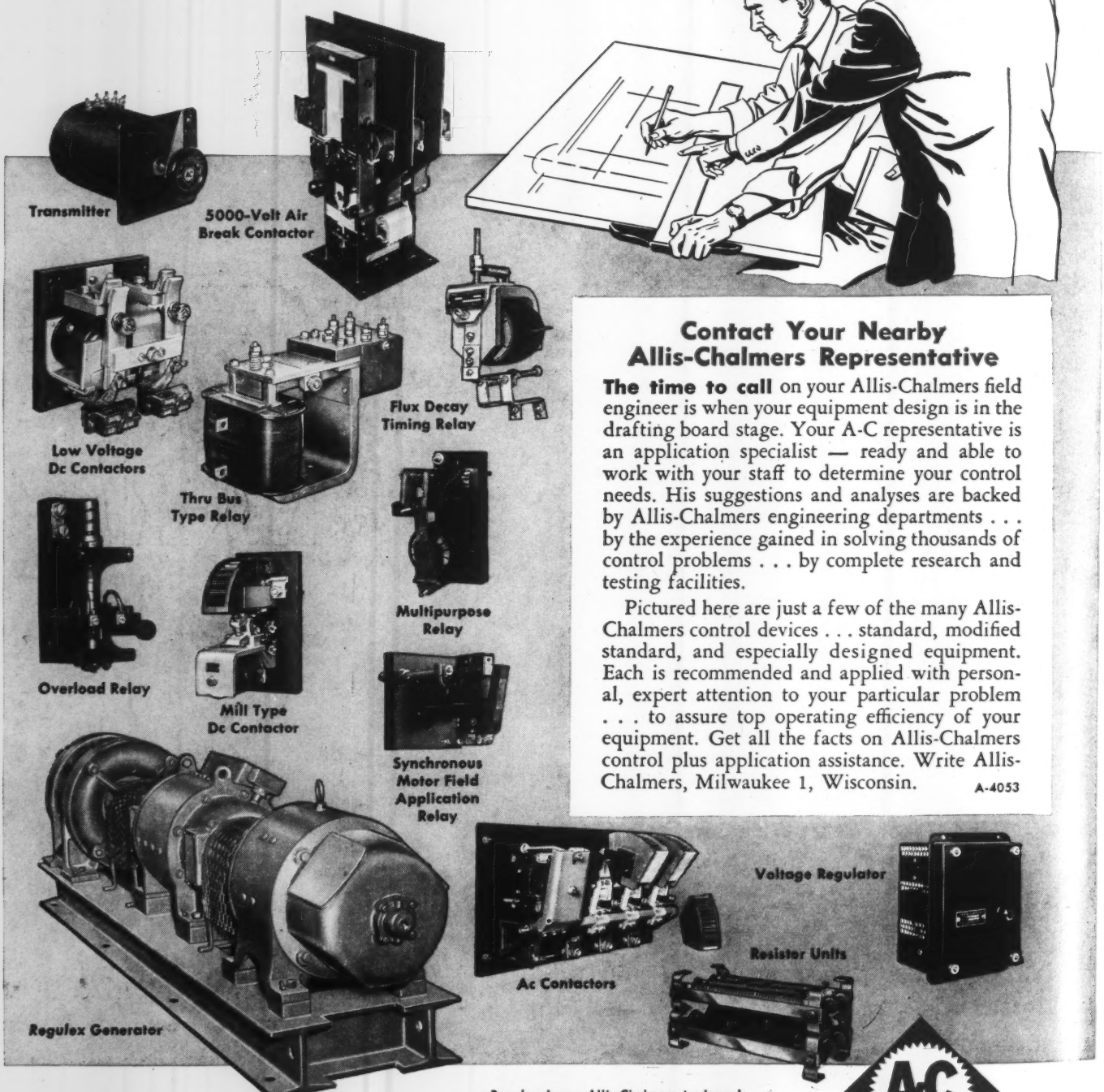

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THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

JULY 1954
Vol. 26—No. 7

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Over the Board

Tooting Our Own Horn

Again this year, we are proud to announce that MACHINE DESIGN has won several awards in the 16th annual *Industrial Marketing* editorial achievement competition. Three awards of merit were bestowed: one for Roger Bolz's article, "Processes and Costs," in our July, 1953, issue (best single article); one for "Hydraulic Control Systems" by R. Hadekel in the April through August issues (best series of articles); and one for our April special issue on Drives and Controls. In winning three awards in a field of over 700 entries, we've now been honored with 17 certificates and plaques, more than any other design publication.

This Month's Cover

Sometimes our cover artist, George Farnsworth, has to be more of an engineer than an artist. In this month's cover, for instance, he was given the problem of epitomizing Paolo Tedeschi's series of articles, "Planning Machines Series," which starts on Page 96. George is a perfectionist. Not content with a mere artistic representation, he set about figuring out the cover according to the methods outlined in the article. As a result, size of the machines pictured and the yellow blocks in which they fit, and the taper on the black wedges, are all designed according to one of the second - order progressions given in the article. With this blend of engineering and art (or maybe in spite of it), the cover does a good job of representing a series of articles which we hope will be of interest to just about everyone.

Answer Me, My Love

Did you see the design engineer who made a brief appearance on the Hit Parade the other evening? A gal named Gisele MacKenzie was singing her heart out for the guy—Answer Me, My Love—while he was elsewhere, busy at his board and working his slide rule overtime. Pretty soon the telepathic waves hit him and he turned away from his project long enough to call her on the phone. But the dope must have gone right back to work again, because Gisele was seen later in the program whooping it up without him. Some engineers ain't human!

Automatic Lei-Making Machine

You'd be surprised at the number of exotic visitors that wander into our editorial offices. One of the most recent was a chap from Honolulu who was touring this country with his 9-year-old son in search of an automatic machine for making leis. Leis—those garlands of flowers draped around the necks of incoming Hawaiian visitors—are a staple item of commerce in the Hawaiian tourist industry. Usually, they are made from either real or crepe-paper flowers strung together. But there's a problem in producing enough of them by present hand methods. Of course, the whole editorial staff promptly volunteered to go out to Honolulu as on-the-spot consultants.

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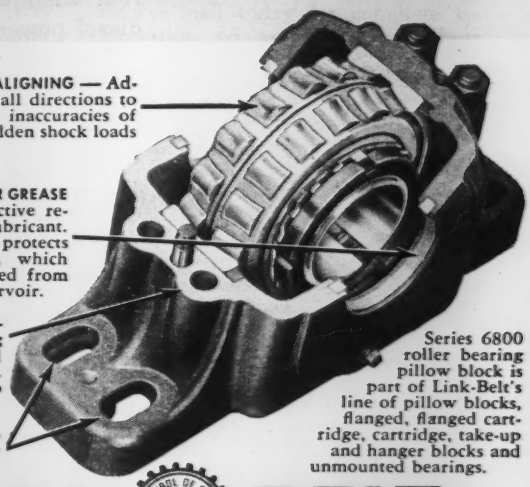

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MACHINE DESIGN

Topics ...IN ENGINEERING AND RESEARCH

Bubble-Blowing May Bring Better Metals

A special bubble-blowing liquid which may be purchased at most ten-cent store toy counters has been improved by GE scientists and used to produce bubbles for metals research. According to Dr. Robert L. Fullman of the GE research labs, the soap bubbles resemble metal crystals or grains in many respects. In particular, the manner in which little bubbles grow into big ones is closely analagous to the growth of metallic grains. Study of the bubbles and the knowledge thereby gained of fundamental behavior of metals is expected to lead to improved metals.

Brighter-than-Sun Flash Unit

A flash tube capable of producing almost a million candlepower per square inch is to be installed at the Bethesda, Md., Naval Hosiptal. Bright sunlight is roughly 800,000 candlepower per square inch. Less than 6 inches in diameter, the lamp, developed by British Thomson-Houston Co. Ltd., retains peak intensity for 1/25-second, long enough to take a color photograph of the retina of the eye to be used in ophthalmic research. Such brilliant, short-duration flashes of light have also been used to photograph changes in living cells.

Turbocruiser—World's First Gas Turbine Bus

A new mobile laboratory for evaluating gas turbines as power plants for automotive vehicles has been built from a General Motors Corp. transit coach. Known as the Turbocruiser, the bus is said to be the world's first. Obvious differences between the Turbocruiser and the conventional bus are the large exhaust opening at the top rear of the bus and a lack of rear windows. Noise level is said to compare with that of a conventional diesel power plant.

New Stainless Steels for High-Temperature Use

A program aimed at finding replacements for scarce materials now used in jet aircraft has resulted in the development of stainless steels with improved high temperature strengths. Developed for the Navy Bureau of Aeronautics by Cornell Aeronautical Laboratory Inc., the new alloys are basically chromium-nickel stainless steels modified with small additions of titanium and boron. Heat treatment and carbon content are also varied to contribute to superior high-temperature properties.

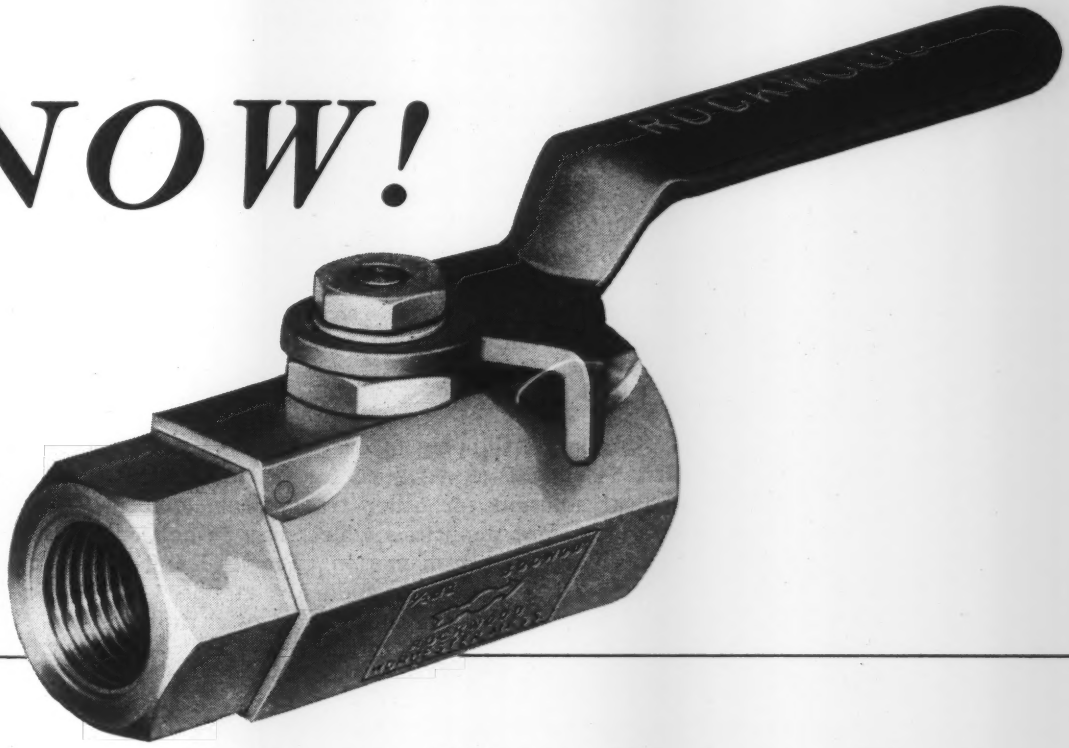
Low-Frequency Mountings Cut Submarine Noise

Expected to provide greater structure-borne noise attenuation than previously available on submarines, low-frequency resilient mountings with unique loading conditions have been developed by the Bureau of Ships. Developed in two sizes, the mountings cover ranges which formerly required eight different-size mountings.

Automation May Be Salvation of Nickel Candy Bar

At a recent meeting, the Pennsylvania Manufacturing Confectioners Association was told of the installation of five automatic candy-bar forming lines in a Midwest plant. The new lines reduce processing time from 16 hours to less than 35 minutes in addition to marked improvement in

NOW!



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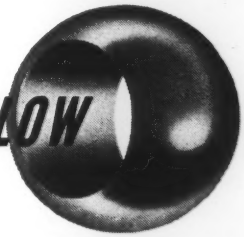
Famous Rockwood ball valves now come in a choice of models. Get the facts on the new, lower cost steel ball valve. Ask for full details on the original bronze or steel ball valves with their *full* round flow and chrome-plated bronze balls. See coupon for sizes — mail today for complete information on any or all of these long-life valves.

ROCKWOOD BALL VALVES



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quality and uniformity. Mr. William J. Scarlett, food industry manager for Minneapolis-Honeywell's Industrial Div., who told the assembled confectioners of the production lines, suggested that such automation of candy production might prevent the five-cent candy bar from following the five-cent cigar into oblivion.

Allergic Phototube Inspects Soft Drinks

Electronically allergic to spots before its eyes, a new phototube developed by the RCA Tube Div., is designed for production-line inspection of soft drinks, medical solutions or other translucent liquids. The tube reacts to minute, transparent impurities which may be bottled inadvertently, but only when the particles are in motion. Bottles being inspected are, therefore, swiftly rotated and then suddenly stopped just before reaching the phototube eye to cause the contents to swirl rapidly.

Air Filter Attracts Dirt Electrostatically

A new "electronic" air-conditioner filter, consisting of two layers of coarsely woven polyethylene plastic fabric in a metal frame, is said to filter 150 per cent more dirt, dust and pollen than glass fiber filters in air conditioner installations. Friction of air drawn through the new Hotpoint Electronic Filter sets up an electrostatic charge that attracts and traps microscopic particles that sift through conventional filters.

Dragon Fur Good Fur Many Things

A new synthetic fiber made from Teflon is so resistant to heat and chemicals that it has been labelled dragon fur. Produced only in experimental quantities at present by the Du Pont Co., the fiber is being evaluated as an industrial fabric rather than for apparel textile uses. High mechanical strength of the material is retained over a range of temperatures from −90 to 400 F. Resistance to chemical attack is demonstrated by its resistance to acids including aqua regia. Projected uses include liquid and gas filtration fabrics, packings, gaskets, diaphragms, and electrical insulation.

Chicken Feathers Make Good Hog Bristles

Paint brushes customarily made from Chinese hog bristles may soon be available with bristles made from chicken feathers. A shortage of hog bristles because of Communist domination of the source resulted in the development, by Arthur D. Little Inc., of a new resilient synthetic fiber made from chicken feathers for their client, the Rubberset Corp. Chemically similar to hog bristle, the new fiber is based on the protein Keratin which is extracted from the chicken feathers and then converted into bristles by a process similar to those used in production of other man-made fibers.

Glo-Quartz Heater Is Real Hot Rod

Described as a wand of fused quartz, a new immersion heater, less than ½-inch in diameter, contains a 400-watt heating coil and glows red-hot for seven of its 12 inches. The remaining five inches remain cool enough to be held in the bare hand. Because of the resistance to thermal shock of quartz, the Glo-Quartz heater, developed by Fisher Scientific Co., may be immersed in a cold liquid while it is glowing hot without cracking, breaking or short circuiting. The heater is also unaffected by acid solutions.

MACHINE DESIGN
JULY 1954

Cut Cost—Not Quality!

MASS production techniques coupled with careful design and redesign for manufacture have wrought miracles in bringing down costs of modern labor-saving machines for the home. For this achievement the design engineers can rightly take much of the credit. But the highly competitive nature of the home appliance business seems to have prompted some manufacturers to carry cost reduction beyond all reason, to the point of cheapening the product.

A certain appliance which for four years had performed yeoman service in the Editor's home recently proved this point by failing in a rather spectacular manner. A high-speed rotating element within the machine suddenly burst, hurling heavy chunks of metal through the sheet-metal housing, fortunately missing three scared people. Two of the pieces, averaging 3 pounds each, were thrown clear with such velocity that the reaction force capsized the 275-pound machine itself.

The mechanics of high speed rotation are well understood, as are such factors as stress concentration, fatigue failure and aging of material. In these times ignorance is no longer a valid excuse for a failure such as described, and it would appear that the material must have been chosen and applied with more of an eye toward saving cost than providing ample safety margin.

In many places it is possible to "get by" with less than the best, where judicious use of low-cost material is plain common sense. But for critically loaded parts the design engineer has a responsibility and an obligation to prove to his management the necessity for specifying adequate strength and reliability, with cost not necessarily the primary consideration.

It has been said that an engineer is one who can do for a dollar what any fool could do for two. Let's reduce costs by all means, but with discrimination and through sound engineering, not by the lazy man's way of cutting quality.

Colin Carmichael

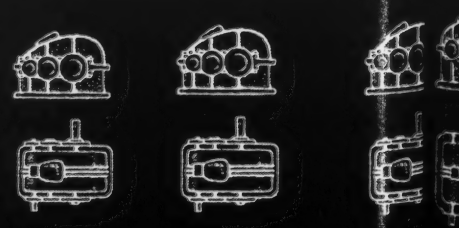
EDITOR

By Paolo Tedeschi
Consulting Engineer
Buenos Aires, Argentina

A MACHINE SERIES =

A rational yet comprehensive planning of machine series has long been a desired goal in design. In the past, pursuit of this objective has been characterized by methods as diverse as the products themselves. Haphazard filling-in and extension of product lines has largely been replaced by intelligent planning. But, attempts to formulate a thoroughly systematic approach have usually foundered on the complex and seemingly irrational problems encountered in co-ordinating engineering, production and commercial requirements. Instead, experience and judgment combined with a few helpful but incomplete techniques have produced entirely adequate results. The ends have often justified the means, whether complete and rational or not.

In this series of articles, an original approach offering a general solution is presented. The aim of these articles is to provide designers with the basic principles and tools necessary for a systematic design approach to rational machine series planning. This first article discusses fundamental concepts and design criteria. Succeeding articles will treat in detail the analytical procedures to be used and the methods of attacking specific problems.



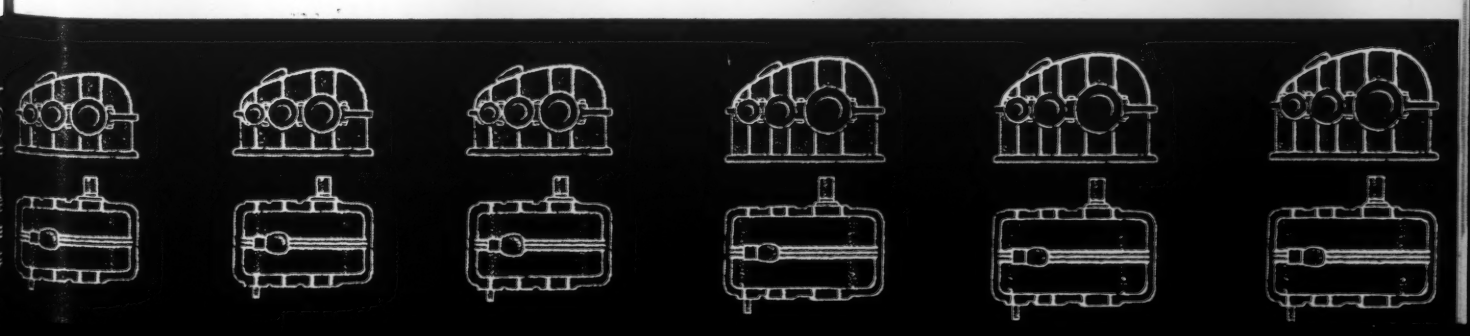
Planning Machine Series-1

- **A family of related units**
- **Similar in construction, operation and purpose**
- **Classed together according to a plan establishing the smallest and largest and the rate of increase in size and rating.**

IN THE INITIAL stages of planning a machine series, development of all models to finished form is not necessary or desirable. Usually, at the beginning, it is sufficient to establish and define the performance characteristics and the basic or general geometrical dimensions of all of the models. Later, the individual units can be developed according to market needs. It is particularly important that the designer avoid the undesirable consequences which may result when, for lack of an organized approach, models are piled on models, in the belief that the range is being covered intelligently merely because each model is larger than the one preceding or smaller than the one following.

Existing standards can have a direct influence on machine series and should be accounted for in early planning. The value of standardization in the case of machine components has sometimes been questioned but is generally well recognized and accepted. For complete machines, however, the reverse may often be true. Standardization of performance requirements for certain types of machinery must be carefully planned; otherwise it may act to hinder improvement and progress.

In these articles, the concept of a "planned" series carries a special significance which should perhaps be clarified. As used here, the terminology takes on an abstract sense, exclusive of any company or type of product. It conveys the idea of



ABOUT THE AUTHOR . . .

A native of Florence, Italy, Dr. Ing. Paolo Tedeschi received his doctorate in mechanical engineering from the Polytechnical School of Milan, Italy, in 1922. He remained with the school from 1924 to 1930, in charge of steam turbine design. In 1931 he became chief engineer of Aeromeccanica Marelli S. A. in Milan, a post which he left in 1940 to join S.I.A.M.—Di Tella Ltda., licensee of the Westinghouse International Co., in Buenos Aires as Chief Mechanical Design Engineer. Since 1945 he has served as a consulting engineer to several companies in Buenos Aires (FAVRA S.R.L., P. Merlini & Hijos S.R.L., etc.) engaged in the manufacture of products ranging in diversity from valves and pumps to power transmission units and cooling towers.

Early in his career, Dr. Tedeschi ". . . was able to perceive the basic criteria for a general study of the problem of planning a machine line and clearly realized that the complete development could not be a work of youth but that of a more advanced age." The methodology and techniques described in this series of articles grew from the studies he performed to fulfill those early objectives.

general applicability in keeping with the design approach. Thus, reference will be to a planned series instead of standard lines, to planning instead of standardization.

Series Limits and Intervals: Establishing the limiting models of a machine series extending over a range of sizes is a vexing problem but, fortunately, is of relatively secondary importance. To determine maximum and minimum model sizes, the designer would have to foresee exactly the future requirements of the industry or industries for which the machines of the series are destined. This task becomes particularly difficult since both limits, especially the maximum one, are dependent on future progress and, often, completely disconnected circumstances which are impossible to predict beforehand. However, the consequences of a mistake in setting the limiting sizes are not as serious as they might seem because the series may be readily extended in both directions without affecting the established intermediate models.

On the other hand, the number of elements in a series, the magnitude of the intervals between successive models and the variation of these intervals are of critical importance and must be correctly determined. From the "technical" point of view, short intervals are desirable. This preference is intuitive and will be explained in numerical terms later. From the economics standpoint, the tendency is to reduce fixed costs as much as possible, leading to a smaller number of models and large intervals. The best answer, as in all engineering problems, is a compromise in which both views are reconciled. The final objective is to determine in each case and for each region of the series the most convenient interval and the most convenient number of models.

Identifying Characteristics: A necessary condition for the formation and design of a series of machines is that the units be mutually comparable. For certain types, as exemplified by hydraulic turbomachines such as centrifugal and axial pumps and hydraulic turbines, the possibility of a series arrangement is established by one constant performance criterion—constant rotational speed, generated pressure, net head, etc.—or by the fixed value of a specific, characteristic or unitary index such as the so-called characteristic number of revolutions. This latter value for turbomachines is characteristic to the extent that it alone will give a specialist in the field an effective picture of the geometrical and operational properties of the machine and, in some cases, will identify certain construction details which would be possible and convenient only with particular values of the index.

Unfortunately, such an index does not exist for all types of machines. Volumetric engines and pumps, for example, must be identified in other ways. In these cases, the characteristic index may take the form of a set of physical and operational system specifications which, if varied, would make it impossible to logically arrange the machines in the same series. For instance, a high-pressure reciprocating pump is adequately identified by the number and position of cylinders, the type of pistons and the maximum normal operating pressure; e. g., triplex vertical plunger pump, 100 atmospheres.

Reference Numbers or Modules: A series is a rational arrangement of sizes. If its formation and development are to be accurately traced, the performance and size of each machine must be clearly represented. This identification can be accomplished by means of two reference numbers or modules.

One of these numbers represents the capacity or rating of each machine, referred to the most suitable property or characteristic in each particular case, and is called the *module of performance* or *operational module.*

The second number must express the geometrical size of the machine directly in terms of the most appropriate dimension of length, area, volume, etc. It is called the *module of geometrical dimension* or simply *geometrical module.*

The two modules must be interdependent. Thus, when one has been arranged in a series, the series formed by the other is automatically traced.

Table 1—Three Types of Geometric Progressions

Term	Progression Type: Constant Ratio* Ratio‡	Constant Ratio* Value	Multiple Ratio§ Ratio‡	Multiple Ratio§ Value	Second Order Ratio‡	Second Order Value
1	...	1	...	1	...	1
2	1.25	1.25	1.6	1.6	1.68	1.7
3	1.25	1.6	1.6	2.5	1.63	2.7
4	1.25	2.0	1.6	4	1.58	4.3
5	1.25	2.5	1.25	5	1.53	6.6
6	1.25	3.2	1.25	6.3	1.48	9.8
7	1.25	4	1.25	8	1.44	14.1
8	1.25	5	1.25	10	1.40	19.7
9	1.25	6.3	1.25	12.5	1.35	26.6
10	1.25	8	1.25	16	1.31	35.9
11	1.25	10	1.25	20	1.27	44.7
12	1.25	12.5	1.25	25	1.23	55.1
13	1.25	16	1.25	31.5	1.20	66.1
14	1.25	20	1.25	40	1.16	76.8
15	1.25	25	1.25	50	1.13	86.5
16	1.25	31.5	1.25	63	1.10	94.5
17	1.25	40	1.12	71	1.06	100
18	1.25	50	1.12	80	...	...
19	1.25	63	1.12	90	...	...
20	1.25	80	1.12	100	...	...
21	1.25	100	...	...	...	...

*Based on American Standard for Preferred Numbers "10-Series."

§Based on American Standard for Preferred Numbers "5-Series," "10-Series" and "20-Series."

‡The ratio for each term is the quotient of the corresponding and preceding term values.

Table 2—Centrifugal Pump Experimental Data

C (gpm)	C_u	η (per cent)	η_u
600	0.4	64.2	0.760
750	0.5	71.0	0.840
900	0.6	76.5	0.905
1050	0.7	80.4	0.950
1200	0.8	82.9	0.980
1350	0.9	84.2	0.995
1500	**1.0**	**84.6**	**1.000**
1650	1.1	83.4	0.986
1800	1.2	79.1	0.935
1950	1.3	72.7	0.860
2100	1.4	60.9	0.720

The most logical operational module would, of course, be one that directly indicates the power or capacity of the machine in the magnitude and units appropriate to the specific case; for instance, power in horsepower or kilowatts for motors, volume in gpm for pumps, transmitted heat in Btu per hour for heat exchangers, etc. However, universal adoption of this procedure for determining the operational module is rendered impossible by some easily understandable difficulties which soon become apparent.

For certain types of machines, the capacity can not always be readily represented by a single physical property. With pumps, for example, both volume and pressure or head must usually be specified. In these cases, the operational module becomes the "resultant" of two or more "components" or, simply, is a property to which these components contribute jointly. For centrifugal pumps, it will be found that the most approximate operational module is the specific volume which is defined as $(\text{volume})/(\text{head})^{1/2}$.

For constant operating conditions, the operational module of a machine can be readily obtained from the analytical expression of its performance. But if, as often occurs, the machine is adaptable to varying operating requirements, the set of properties or characteristics to be taken as a basis for the operational module cannot usually be evaluated without previous investigation, dependent, of course, on the particular factors involved.

As previously defined, the geometrical module expresses the machine size in terms of a dimension. This dimension may be of length, area, volume or sometimes may be an expression of a power superior to the third. Ideally, the dimension selected for a particular machine should be the one most suited to represent machine size and, also, to be interdependent with the operational module.

When both modules have been determined, a relation between the two terms must be established. This relation can be expressed analytically and may be of either rational or empirical-experimental origin.

As will be shown later, this relation usually

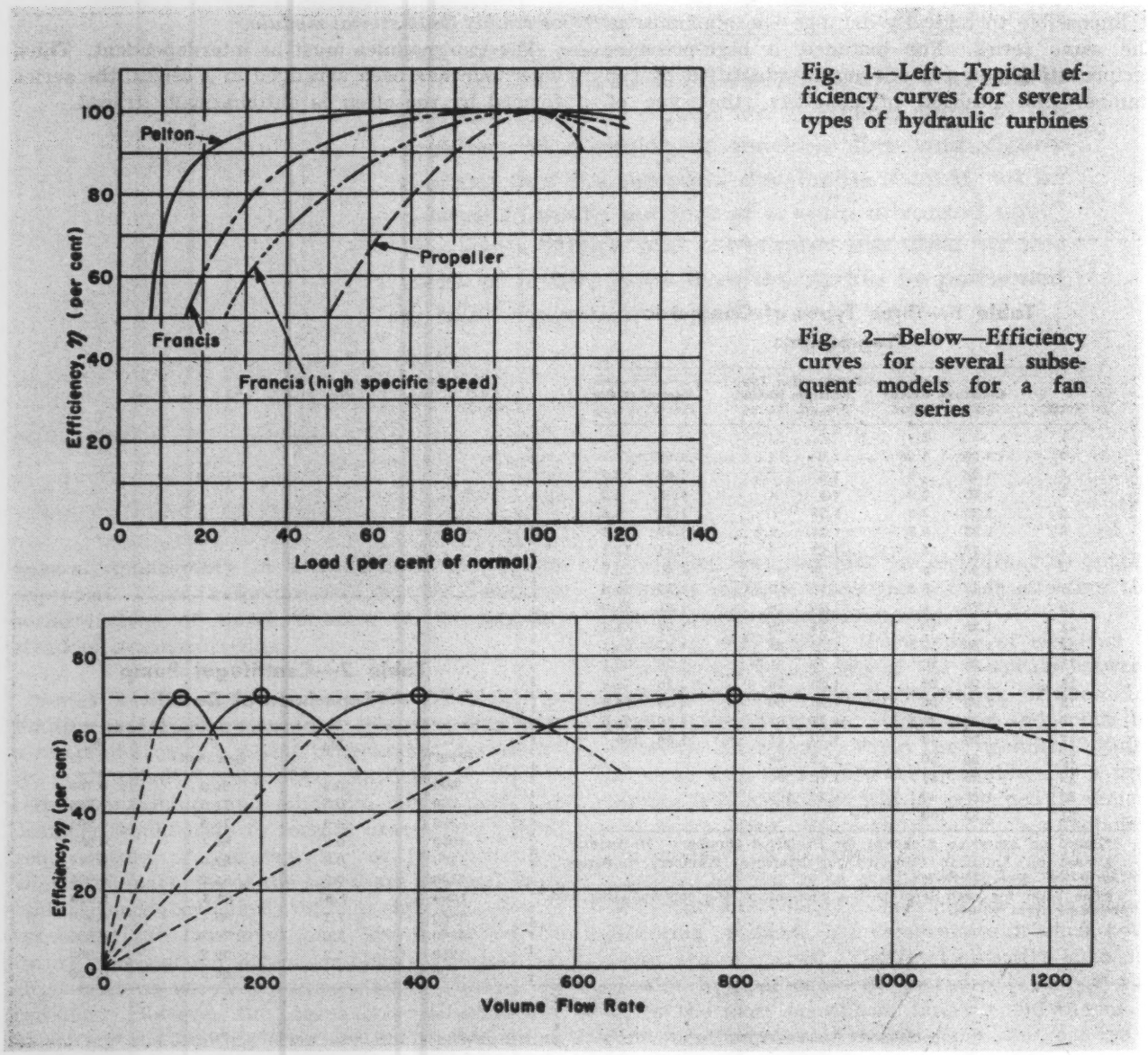


Fig. 1—Left—Typical efficiency curves for several types of hydraulic turbines

Fig. 2—Below—Efficiency curves for several subsequent models for a fan series

takes the form

$$W = k L^{\epsilon} \quad \ldots\ldots (1)$$

where W is the operational module, L the geometrical module and k and ϵ are constants for the particular series. This form of relationship between the two modules has a particular usefulness in design and acts to facilitate the development of the corresponding machine series.

Mathematical Tools: In selecting a suitable series grouping of modules, the designer has several possible approaches available. Mere intuition is often confirmed by rational analysis.

A familiar mathematical procedure for deriving a sequence of terms is the arithmetic progression in which each term differs from the preceding one by a constant amount. However, for most engineering practice and especially in the area of standardization it is well recognized that arithmetic progressions, in spite of their apparent orderliness and simplicity, are actually completely irrational. Adoption of this type of progression for a machine series would in effect compel acceptance of intervals which would not be justified or logical over the entire series range.

A good picture of the difficulties encountered is furnished by analysis of a possible series of electric motors with outputs going from 1 to 100 hp approximately. For an arithmetic progression with an interval of 2 hp, only a few initial terms would be acceptable; with an interval of 10 hp only a few end terms; and with an intermediate size interval of say 5 hp, only a narrow central portion of the series would meet normal requirements.

A definite improvement can be obtained through use of another familiar mathematical tool—the geometric progession. For this type of progression, which is used as the basis for the well-known

* *American Standard Preferred Numbers*—ASA Z17-1936 (Reaffirmed 1946)

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American Standard preferred number series*, the intervals grow in proportion to the term values and the successive terms are usually the product of the preceding term multiplied by a constant. Referring back to the proposed electric motor line and using the ASA "10-series" which has a constant ratio of 1.25, the series shown at the left hand side of *Table* 1 (constant ratio type) is obtained. On the basis of normal industrial and commercial requirements this series would be acceptable in the zone between 4 and 63 hp, but not beyond these limits.

A complete solution to this problem, at least from the intuitive point of view, might possibly be reached by one of the two following methods: (1) Use a group of subsequent geometrical progressions, each having a different ratio, or (2) determine a special progression with a continuously varying ratio. An example of the first alternative is given by the middle series, *Table* 1, which uses 3 groups of progressions and has 20 terms.

The second method of solution is exemplified by the 17-term series, shown at the right-hand side of *Table* 1, in which the values have been approximated to the nearest tenth and the ratios have been rounded off to the second decimal figure. To form this series, a decreasing progression of ratios has been employed. This series of ratios is also a geometric progression with a constant ratio less than one; for this case the ratio is 0.970.

The mathematical theory and practical applications of this last series, which may be defined as a *second-order geometrical progression,* will be discussed in future articles. This type of series offers the best approach for meeting practical de-

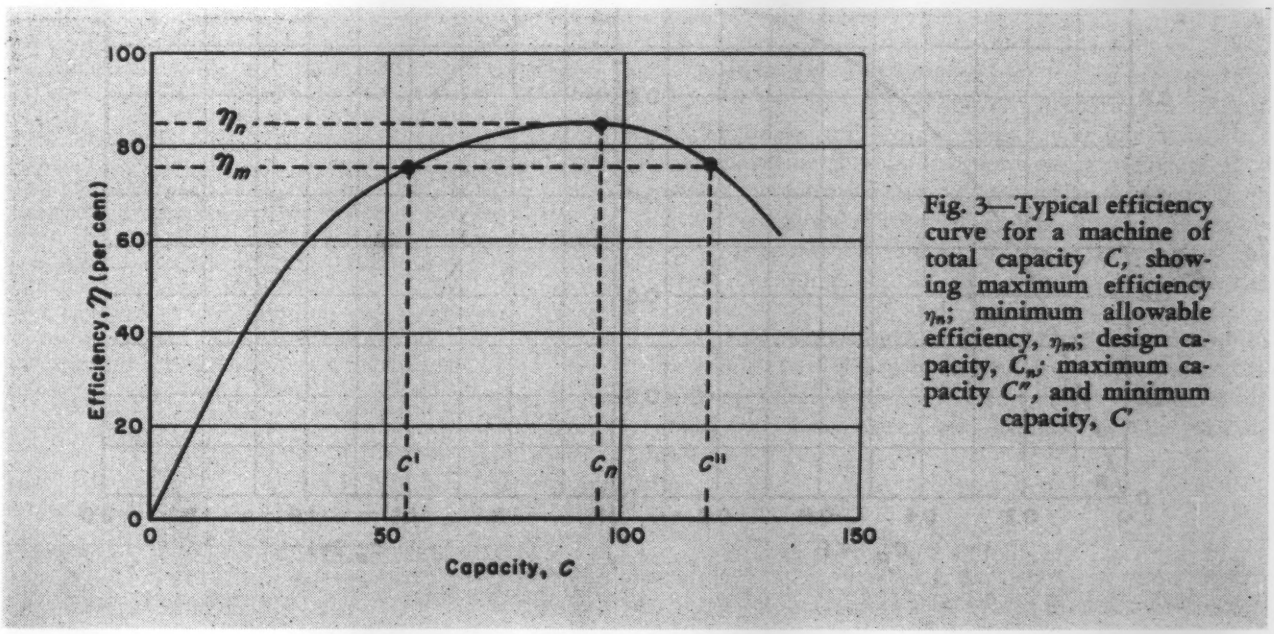


Fig. 3—Typical efficiency curve for a machine of total capacity C, showing maximum efficiency η_n; minimum allowable efficiency, η_m; design capacity, C_n; maximum capacity C'', and minimum capacity, C'

sign requirements and generally serves as the reference point for the developments which form the basis of these articles. Sometimes, groups of conventional geometrical, or even arithmetic, progressions may be used as substitutes but these only serve as practical approximations with the special progression still remaining as the fundamental guide.

Efficiency Criteria: With only a few exceptions, the total efficiency of a machine will vary with load according to a curve which rises to a maximum height and then drops until the abscissa co-ordinate of maximum load is reached, limited by circumstances which are generally independent of efficiency. The load value at maximum efficiency is generally considered the normal or design load.

Actual shape of the load-efficiency curve will vary for different types of machines. In many instances, the form is so characteristic that a specialist can determine the exact machine type merely on examination of the curve appearance, *Fig.* 1.

Similar machines belonging to the same series will have efficiency curves similar in form. Maximum curve height will rise gradually as machine size increases since the losses accompanying any transformation of energy are proportionately decreased as absolute machine magnitude becomes larger. However, this increase of maximum efficiency may be ignored initially and it can be safely assumed that the curves for the series units may be derived from each other on the basis of a proportional relationship between corresponding abscissas. Thus, for each efficiency value, the abscissas of the curves for different machine sizes will differ by a constant factor determined by the ratios of their normal capacities. As shown in *Fig.* 2, a plot on the same chart of the efficiency curves of two or more similar machines of different sizes produces a set of homologous curves. A closer examination of these curves will be helpful in developing some of the fundamental criteria essential to rational machine series planning.*

An efficiency curve for a machine of capacity C is shown in *Fig.* 3; η_n is the maximum efficiency, η_m is the minimum allowable efficiency and C_n is the normal or design capacity corresponding to η_n. A horizontal line representing the minimum allowable efficiency, η_m intersects the efficiency curve at two points having corresponding abscissas of C' and C''. These two abscissas represent minimum and maximum capacities, respectively, limiting the application range of a machine which has to operate at an efficiency not less than the minimum, η_m.

Two useful relationships for expressing curve properties are:

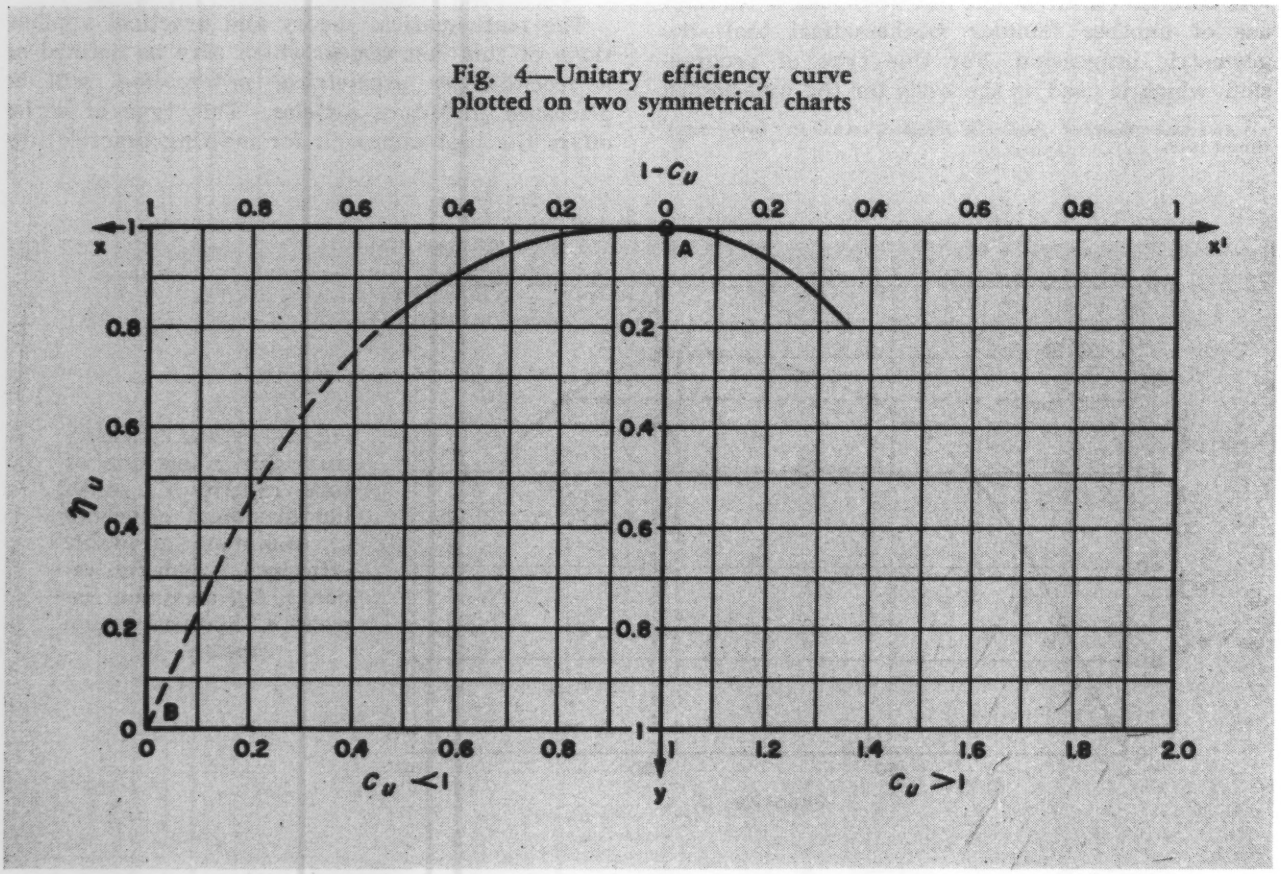
$$\alpha = \frac{\eta_n}{\eta_m} \quad \ldots\ldots (2)$$

$$\beta = \frac{C''}{C'} \quad \ldots\ldots (3)$$

where α is defined as the factor of efficiency loss.

* It is interesting to note that the idea of interdependence between formation of a machine series and the related efficiency curves is attributed to the French engineer L. Bergeron who mentioned it briefly in an article published in 1922, dealing with the case of centrifugal pumps.

Fig. 4—Unitary efficiency curve plotted on two symmetrical charts



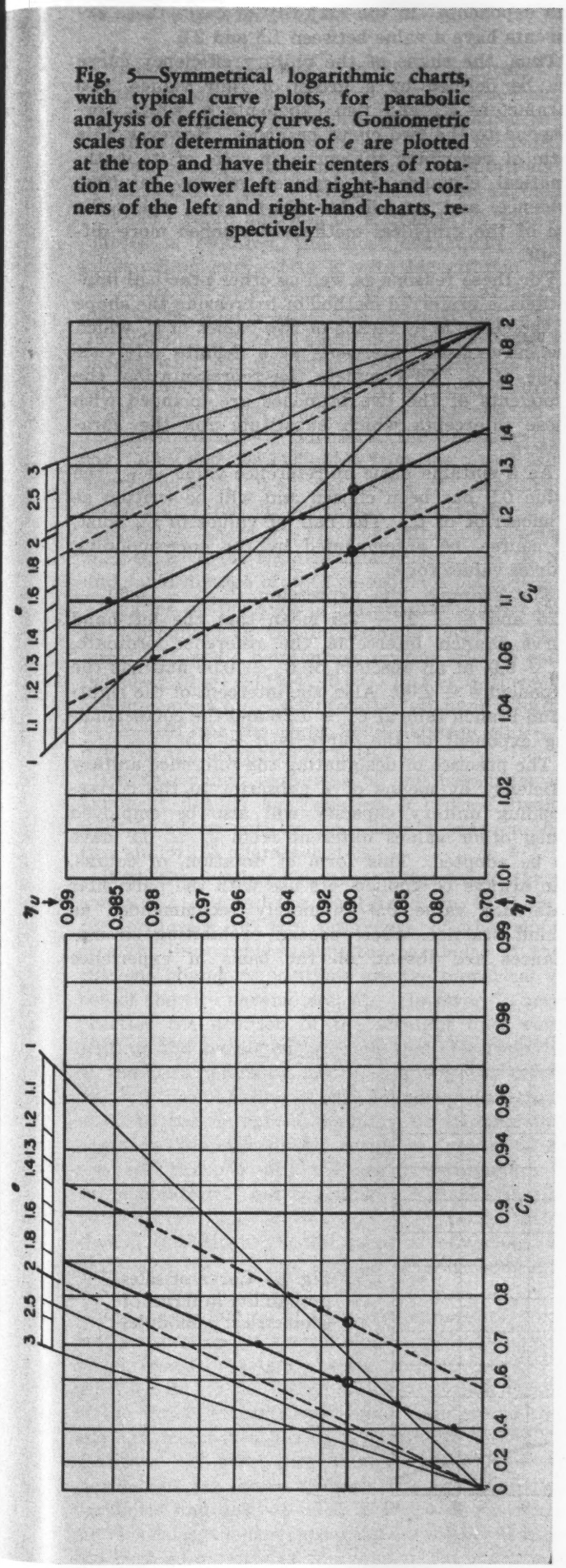


Fig. 5—Symmetrical logarithmic charts, with typical curve plots, for parabolic analysis of efficiency curves. Goniometric scales for determination of e are plotted at the top and have their centers of rotation at the lower left and right-hand corners of the left and right-hand charts, respectively

It is evident that the value of β depends on the shape of the curve and is an increasing function of α. The ratio β may perhaps be most aptly defined as the shape index of the curve and its value will increase as the curve becomes flatter in the region of maximum efficiency. Since the efficiency curves for similar machines have the same shape, if a constant factor of efficiency loss, α, is assumed, β will also be constant.

If, from the standpoint of economics, the minimum allowable capacity established for each unit must coincide with the maximum of the preceding one, and vice versa, the ratio between these minimum capacities becomes approximately equal to that of the normal or design capacities for two subsequent units. Thus, if β is constant, the series formed by the sequence of normal or design capacities coincides with the terms of a geometrical progression with ratio β. This relationship offers a rational basis for justifying the adoption of the geometrical progression as a fundamental guide for tracing the formation of a series of modules, having, in this case, the character of operational modules.

Further investigation also justifies the use of a decreasing ratio from the first to the last term of the series. As a matter of fact, based on principles of elementary economics larger losses of efficiency are permissible in small machines than in large ones. This means that α must decrease accordingly. The shape factor β, which is a direct function of α, must also decrease progressively, thus establishing a geometrical progression of decreasing ratio or one of the type defined as "second order."

Thus, analysis of physical and economic factors produces the same conclusion reached previously by intuition.

Significance of Curve Shape: In the previous discussion of efficiency curves, attention has been called to the importance of curve shape as a prime consideration in the rational determination of a series of operational modules—at least, where such a curve has meaning and can be plotted. Perhaps, at this point, it would be best to clarify the exact meaning of the expression, "shape of the curve."

In the discussion to follow, it will be helpful to introduce two concepts which are designated as the unitary efficiency, η_u, and the unitary capacity or load, C_u. These terms are defined by the expressions

$$\eta_u = \frac{\eta}{\eta_n} \quad \text{.....(4)}$$

$$C_u = \frac{C}{C_n} \quad \text{.....(5)}$$

where η_n and C_n are the design efficiency and capacity, respectively, and η and C represent efficiency and capacity values corresponding to any point on the efficiency curve.

A typical plot of η_u and C_u values is shown in *Fig.* 4, the curve having its origin at point *B*. In addition to the values of η_u and C_u, the complementary values to unity, $(1\text{-}C_u)$ and $(1\text{-}\eta_u)$, have also been indicated on the scales. For purposes of these articles, only the absolute or numerical (instead of the algebraic) value of the term $(1\text{-}C_u)$ will be considered, since negative values would otherwise result in the overload range.

A more convenient arrangement of curve axes is obtained if the origin is established at the normal point *A* and the abscissas in both directions, along Ax and Ax', are considered positive. Referred to these new axes, both branches of the curve take the form of parabolas with coincident axes.

Results of Curve Analysis: By limiting the investigation of η_u to values near 1, which is the significant zone, and by analyzing a large number of experimental curves in this region, it has been found that each branch of the curve, *Fig.* 4, follows with good approximation a parabola of the form defined by:

$$(1 - \eta_u) = K_p\,(1 - C_u)^e \qquad (6)$$

where K_p is a parametrical constant and e is the exponent of the curve. The two curves might be best described as equivalent parabolas; their location on the right or left-hand side will depend on whether the values of C_u are larger or smaller than 1, respectively.

Another important characteristic determined from the curve analysis is that the right and left-hand parabolas generally have different parameters and exponents. In the majority of cases these exponents have a value between 1.5 and 2.5.

Thus, the shape of the unitary efficiency curve can be defined by a group of four values, two parameters K_p and two exponents e, which correspond to the two curve branches. However, this form of describing the curve, in spite of its mathematical elegance, is deprived of any intuitive evidence, and, as will be shown later, makes the use of the graphical methods developed more difficult.

For these reasons as well as other practical limitations, a preferred method of expressing the shape of the curve is by means of two values of C_u which the curve itself intercepts at a definite reference value of η_u. To complete the representation, the exponents of the two branches are included with these intercepts which substitute for the parameters.

As a suitable basic or reference value of η_u, the value 0.9 has been chosen and will be written as a subscript of C_u. The pair of values of C_u must, of course, be accompanied by the corresponding pair of values for e.

For example, the expression $C_{u,0.9} = 0.60 - 1.26$ and $e = 2 - 2.5$ mean that the left-hand curve branch intercepts the reference ordinate, $\eta_u = 0.9$, at an abscissa of $C_u = 0.60$ and has the exponent $e = 2.00$. Also, the intercept of the right-hand branch falls at $C_u = 1.26$ and the corresponding exponent of the curve is $e = 2.5$.

The practice of designating the reference unitary efficiency by means of a subscript to the corresponding unitary capacity will also be employed when other values different from $\eta_u = 0.9$ have to be adopted. This form of notation, of course, can always be applied; its use with the particular reference value 0.9 is merely recommended as sound practice, where special prohibiting circumstances are absent, on the basis of experience

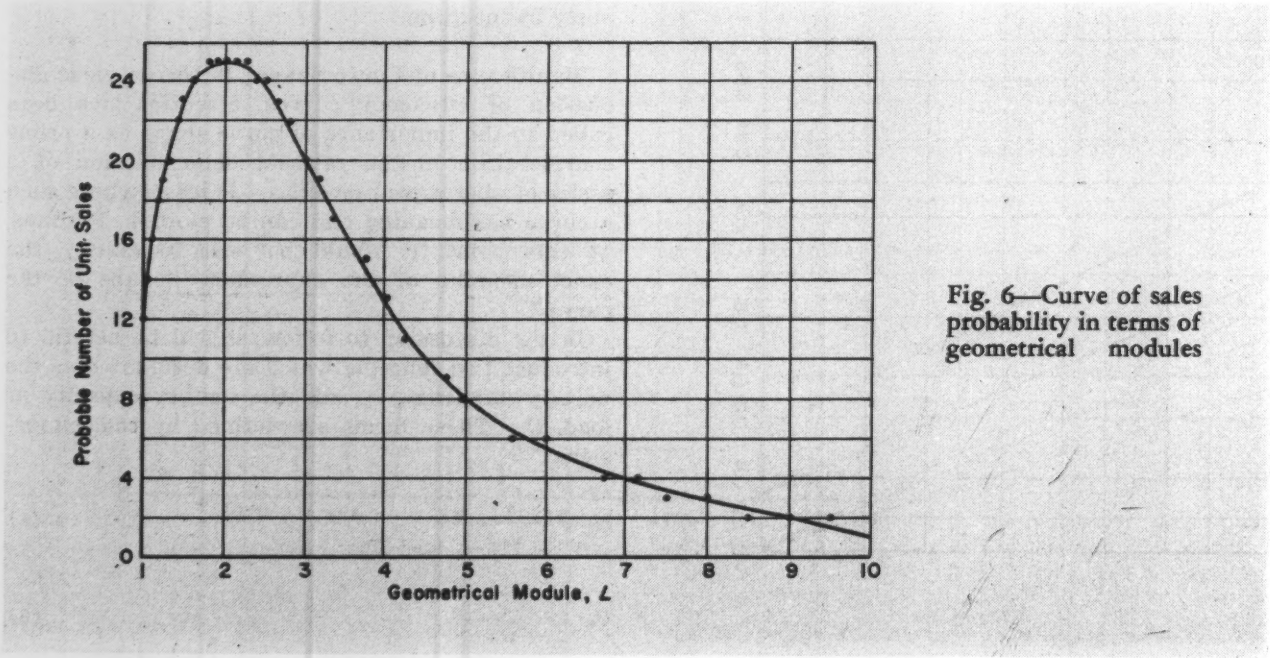


Fig. 6—Curve of sales probability in terms of geometrical modules

gained with numerous actual curves.

Graphical Approach: "Parabolic analysis" perhaps best describes the study of efficiency curves in accordance with the criteria established in the foregoing discussion where the curve is identified by two parabolas and the descriptive notations are synthesized in two intercepts and two exponents.

Where rapid analysis of a number of parabolic curves is required, the most convenient method of handling curve data is with logarithmic paper. Like the Cartesian chart, *Fig.* 4, the new diagram has to be double-sided and symmetrical, *Fig.* 5. In plotting the new diagram, starting from two points with an arbitrary distance between them, two systems of co-ordinate axes must be drawn. Scale graduations along these axes will be determined from two functions, the abscissas from log $(1\text{-}x)$ and the ordinates from log $(1\text{-}y)$ where the expression $(1\text{-}x)$ represents its absolute or numerical value only (values are positive in any case, also where $x>1$). For left-hand abscissas $x = C_u < 1$, for right-hand abscissas $x = C_u > 1$ and for ordinates of both co-ordinate plots, $y = \eta_u$.

Origins on the axes of a Cartesian chart cannot be reproduced in the logarithmic image. Consequently, for the new curves origins will be established at $(1\text{-}x) = (1\text{-}y) = 0.01$. In *Fig.* 5, these values appear as $C_u = 0.99$ for the left hand diagram, $C_u = 1.01$ for the right hand diagram and $\eta_u = 0.99$ for the ordinates of both.

On this chart, parabolas of any parameter and exponent defined by Equation 6 become straight lines in which position and slope depend on these two analytical characteristics.

With the left-hand diagram extended to the abscissa $C_u = 0$ and the right-hand one to $C_u = 2$, the ordinates of the intercepts of the sloping straight lines representing the parabolas at those extreme boundary positions are the numerical values of the two parameters, K_p. However, in actual practice the position of the straight lines representing the parabolas is such that determination of the parameters by means of the graph usually requires prolongation of the boundary lines downward to the extent of doubling or tripling chart height. This undesirable result is another of the practical reasons why the use of parameters for curve notation is not advisable. With the abscissa reference method of notation, the plotted values always fall within the limits of a convenient diagram size, *Fig.* 5, and can be read without difficulty.

For determination of the curve exponents, which are a function of curve slope, two goniometric scales based on trigonometric tangents have been provided in *Fig.* 5. These scales have their centers in the lower left and right-hand corners and their angular origin in a direction parallel to the axis of abscissas. If, from these centers, lines are drawn parallel to the lines representing the equivalent parabolas and are extended to intersect the goniometric scales, the corresponding curve exponents, e, can be read directly at the point of intersection.

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The procedure for analyzing experimental data by means of the chart is illustrated by the following example.

The results of an experimental test to determine the efficiencies of a centrifugal pump at different volume rates of flow are given in *Table* 2 along with the calculated values of C_u and η_u. Normal or design capacity at $\eta_u = 1$ is 1500 gpm.

Corresponding pairs of values of C_u and η_u determine points on the chart and are plotted accordingly in *Fig.* 5 on the left or right-hand sides, depending on the magnitude of the value of C_u. For each side, straight lines are drawn through the points, averaging any misalignments in point distribution, as shown by the heavy solid lines in *Fig.* 5.

Values of $C_{u,\,0.9}$ may be determined directly from the two plotted curves as the abscissas of the two points located by the ordinate $\eta_u = 0.9$, which is the unitary efficiency reference value, giving, in this case, $C_{u,\,0.9} = 0.59\text{-}1.25$. Values of C_u for any other values of η_u, may also be readily obtained in the same manner.

Values of the exponents, e, for the two curve branches are found at the intercepts on the goniometric scales of lines drawn parallel to the curve plots and passing through the goniometric scale origins. In this case the intercept values are $e = 2.28\text{-}2.10$.

The chart is also useful in other ways. Assume that a curve, different from the foregoing, has only its reference values, $C_{u,\,0.9} = 0.75\text{-}1.15$ and $e = 2.0\text{-}1.8$, given and the values of $C_{u,\,0.92}$ and $C_{u,\,0.98}$ must be determined. The first step is to establish the two curve branches as shown by the heavy dotted lines in *Fig.* 5. For the left-hand side, the curve plot is a straight line passing through the point $C_u = 0.75$, $\eta_u = 0.9$ and having a slope equal to $\tan^{-1} 2$. For the right-hand side, the linear curve plot passes through the point $C_u = 1.15$, $\eta_u = 0.9$ and has a slope equal to $\tan^{-1} 1.8$. These inclinations may be readily determined directly by means of the goniometric scales, reversing the procedure used in the previous example. The required values of C_u may now be read directly from the curve at the points given by the ordinates $\eta_u = 0.92$ and $\eta_u = 0.98$. Thus, $C_{u,\,0.92} = 0.772\text{-}1.132$ and $C_{u,\,0.98} = 0.887\text{-}1.062$.

For a machine series where many efficiency curves of machines of the same kind are involved, the method of analysis just described will establish the most probable shape of the efficiency curve in only a few values of $C_{u,\,0.9}$ and e. Without the graphical aids described, this synthesis would be practically impossible since it would entail the construction of parabolic curves from unknown data on Cartesian co-ordinates.

Thus, it is evident that minimum and maximum values of C_u, and the related shape coefficient β,

Cost Calculations

Problem: To determine a series of minimum total cost

Given:

(1) Three different conditions of fixed cost equal to 3, 5 and 10 times the production cost for one unit of each model

(2) Five possible series progressions of 41, 21, 11, 6 and 5 terms

(3) Geometrical modules of first degree (linear)

(4) Ratio of largest and smallest geometrical modules equal to 10

(5) Production cost proportional to the square of the geometrical module

(6) Recovery of fixed charges when 593 machines are manufactured.

Calculation Procedure:

(1) Calculate total production cost for each series. Sample calculations for 11-term series shown.

Term	Module	Unit Production Cost F	Unit Quantity n	Total Production Cost Fn
1	1.00	1.00	12	12.00
2	1.25	1.60	67	107.20
3	1.60	2.50	89	222.50
4	2.00	4.00	99	396.00
5	2.50	6.30	98	617.40
6	3.15	10.00	84	840.00
7	4.00	16.00	61	976.00
8	5.00	25.00	38	950.00
9	6.30	40.00	24	960.00
10	8.00	63.00	14	882.00
11	10.00	100.00	7	700.00
		$\Sigma F=269.40$	$\Sigma n=593$	$\Sigma Fn=6,663.10$

Fig. 7—Cost data calculations and corresponding curve plots of data for determining the number of models to provide a minimum total cost of production for three cases of different fixed costs. Calculations are based on five series progressions of 41, 21, 11, 6 and 5 terms

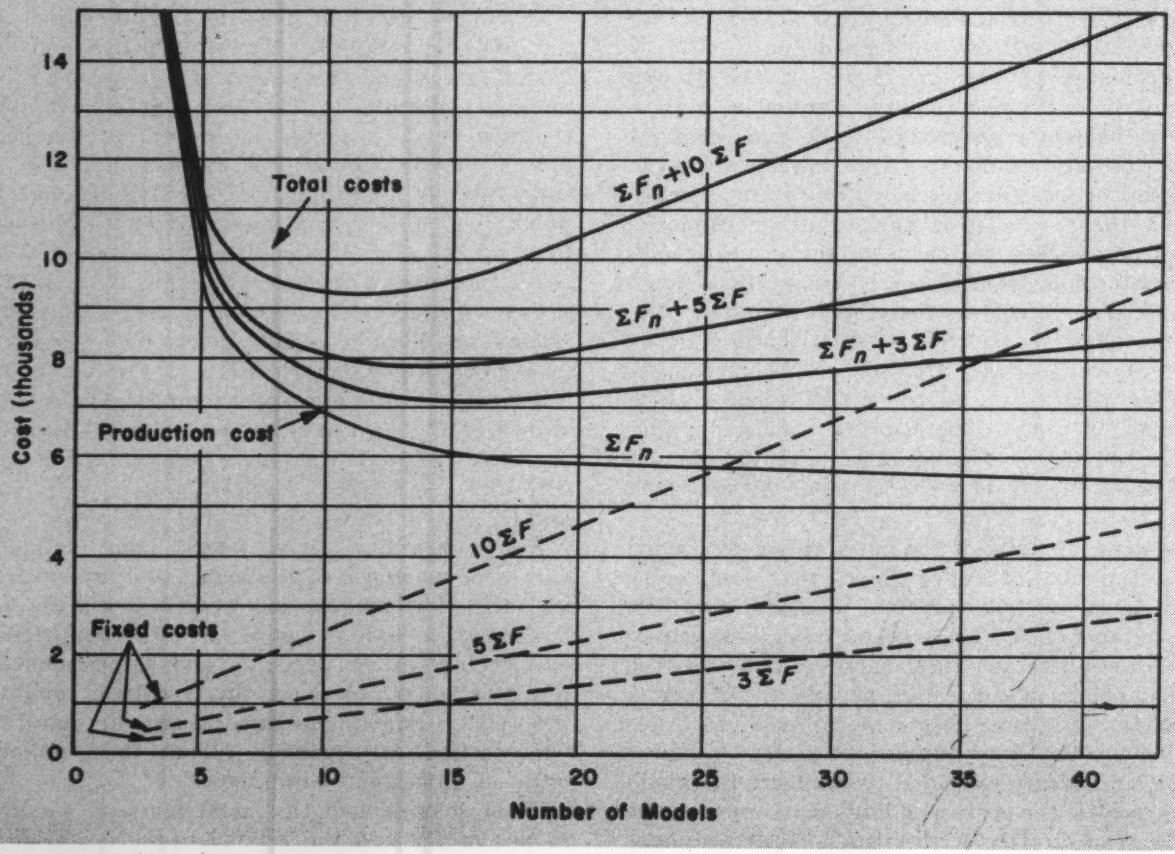
(2) Calculate total cost of series for each of the different fixed costs. Sample calculations for 11-term series are given.

	1	2	3
Total Production Cost	$\Sigma Fn=6,663$	$\Sigma Fn=6,663$	$\Sigma Fn=6,663$
Fixed Costs	$3\Sigma F=807$	$5\Sigma F=1,345$	$10\Sigma F=2,690$
Total Series Costs	7,470	9,008	9,353

(3) Compare total series costs.

Summary of Calculated Data

Number of Models	41	21	11	6	5
Ratio of Model Progression	1.06	1.12	1.25	1.60	1.80
Ratio of Cost Progression	1.12	1.25	1.60	2.50	3.15
	Total Costs				
Fixed Cost= $3\Sigma F$	8,356	7,369	7,470	9,041	10,144
Fixed Cost=$10\Sigma F$	14,747	10,750	9,353	10,203	11,166
Fixed Cost= $5\Sigma F$	10,182	8,355	9,008	9,871	10,436



may be readily determined, basing the determination on the smallest allowable value of η_u. Usually, β will be the same as the ratio between normal capacities and, consequently, the progression ratio to be adopted when the criterion of allowable efficiency loss is the dominant factor in series planning.

Production Costs: Minimum allowable efficiency, as a planning criterion, can not always be applied without reservation. If the efficiency curve is flat, a desirable characteristic in any well-designed machine, such a criterion would lead to excessively large intervals and too small a number of models. On the other hand, if the efficiency curve bends sharply or the field of application is limited by other unfavorable characteristics, the need for continuity of subsequent application ranges would lead to acceptance of too large a number of models.

Even in cases where the concept of efficiency loss is applicable, results must be checked with others, derived from more immediate economic considerations that are based on production and fixed costs.

Production costs of a set of machines arranged in various series groupings with different numbers of elements will decrease as the number increases, if fixed costs are disregarded. In effect, a minimum cost is attained when, for each specific application, the machine that exactly fits the operational requirements is produced. If the machines belong to a series, however, the capacity of each will always exceed the required capacity, resulting in increased size and cost.

Considering now the fixed charges for research, engineering and production—drawings, foundry patterns, stamping dies, gages, jigs, fixtures, etc. —it is apparent that these charges will vary inversely to production costs and will increase with the number of terms of the series since every new model added requires additional engineering expense.

Total cost, of course, is the sum of the two. Since the variation between the two follows an inverse pattern, it is possible and probable that a certain number of series elements can be found where total costs approach a minimum value. This consideration offers another guide to rational series planning.

The following example may be helpful in clarifying the application of this concept to series planning.

Assume a series of machines having a geometrical reference module, of first degree (linear), which increases from a minimum value 1 to a maximum 10. The elementary theory of similarity of dimensions and weight, from the standpoint of costs, indicates that the production costs of machines of a series are, in general, proportional to an exponential of the geometrical module. Frequently, this exponential power is 2. For convenience, the series under analysis will be assumed to follow this law. Additionally, it will be assumed that the total number of machines to be manufactured in all model sizes of the series is approximately 600 and that engineering costs are completely recovered by this quantity.

It is obvious that sales of different sizes will not be uniform. Generally, the smaller models will have a better market than the larger sizes. In some cases, best sales may occur with intermediate sizes. For determination of the probable sales market, the curve in *Fig.* 6 can be used. Assuming that no machines are made for stock, this curve will also give the number of separate model units to be manufactured. In this chart, models are represented along the abscissa by their geometrical modules.

From a comparison of five different series of geometrical modules, lying between the limits 1 and 10, the most convenient number of models can be determined. Four of these series are American Standard preferred numbers groupings, specifically the 40, 20, 10 and 5-series, and consist of 41, 21, 11 and 6 terms respectively. The fifth series is a 5 term nonstandard progression.

The chart in *Fig.* 6 is based on the first of these series groupings; namely, the one composed of 41 terms. The others are derived from the first, omitting every other term to obtain first the 21-term series, and then the 11-term and the 6-term groupings.

Concerning the manufacture and sale of the different models, it will be assumed that, if on passing from one series to the other some of the models are eliminated, an equal number of machines of the nearest larger size will be manufactured and sold, according to the criterion of using the next larger size whenever one model of the primitive series is missing. Thus, the total number of machines to be produced remains constant for all of the series, while the number of units of individual models increases as the number of models decreases.

Fixed costs are assumed to be a multiple of the production cost for each model. To investigate the influence of fixed costs on total cost three different cases will be presented, assuming that fixed costs are respectively, 3, 5 and 10 times greater than production costs. Accordingly, the fixed costs for a complete series will, in the three given cases, be 3, 5, or 10 times the total production cost for one unit of each model.

This basis for cost calculation has been employed for the five series groupings mentioned previously, producing the tabularized results shown in *Fig.* 7. For the 11-term series, the complete calculation procedure is shown; however, for the other series only the final results are summarized. A graphical interpretation of these cost data is also shown in *Fig.* 7.

From the curve plot in *Fig.* 7, it is evident that the most convenient zone lies between 6 and 21 terms. It must be remembered that these data concern a series of geometrical modules with limiting values of 1 and 10 and that the type of pro-

gression adopted for series arrangement is the constant ratio progression serving as a basis for the American Standard for preferred numbers. Thus, the progression ratios corresponding to the different series which fall into the desired zone on *Fig.* 7 of 6 to 21 terms have a range of values from 1.58 to 1.12. Referring to the earlier discussion on types of progressions, it is evident that the variable ratio of the second order geometrical progression fits within these limits, if this type of progression should be adopted for series planning.

The curves in *Fig.* 7 also show that fixed cost, perhaps the most disputable factor of this whole analysis, is not of primary importance since its variation over the most desirable flat curve range from 11 to 16 terms, which represent the series of minimum cost, corresponds to the variation over the range from 3 to 10 times the total production cost for one unit of each model.

Obviously, the previous analysis represents only a tentative approach applicable to those cases where fixed costs have an importance comparable to that of the example. In the mass production of machines or appliances where large stamping dies, special machine tools, and other expensive equipment may be required, fixed costs may become such a decisive factor that selection of the number of models to be manufactured will depend on the general financial structure of the company.

Commercial Considerations: These considerations are perhaps the most vaguely defined, but at the same time are the most important, especially from the viewpoint of sales. They have as a basic tenet the condition, similar to that discussed in reference to production costs, that the selling price of machines in a series decreases as the number of models increases; that is, as the series becomes more dense. It is apparent that a manufacturer with a dense line is able to offer machines with capacities nearer to those requested in each case by a buyer than would a manufacturer with a smaller number of models. The latter would have to offer larger and more expensive machines to meet buyer specifications because of the larger series intervals in his less dense line. It is interesting to note that this elementary concept is often overlooked by manufacturers, possibly because of the difficulty in distinguishing the business lost by virtue of the faulty series from that lost for reasons of a more directly commercial nature.

As in the case of production costs, the advantages of a dense series are rapidly counterbalanced by certain negative factors, such as stagnation of capital by stocks and charges of commercial organization, which partly depend upon the total number of models. Nevertheless, from a strictly commercial point of view, these disadvantages are not of a significance to rule out the benefits of a relatively dense series.

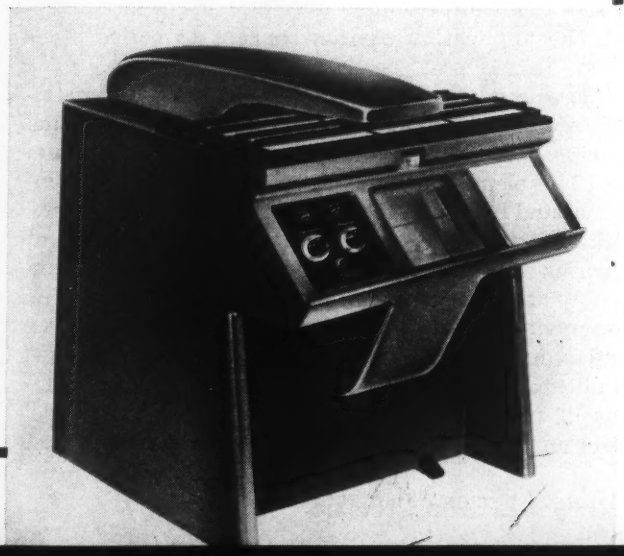
Thus, it is apparent that when, on the basis of efficiency loss or production costs or both, a certain range of terms or of progression ratios is being determined, commercial considerations will lead to a choice of a larger number of models rather than a smaller, to a lesser progression ratio rather than a greater.

In the second article of this series, attention will be devoted to the analytical aspects of machine series planning. Second order progressions, their properties and their usefulness as a planning tool will be treated in detail.

CONTEMPORARY DESIGN

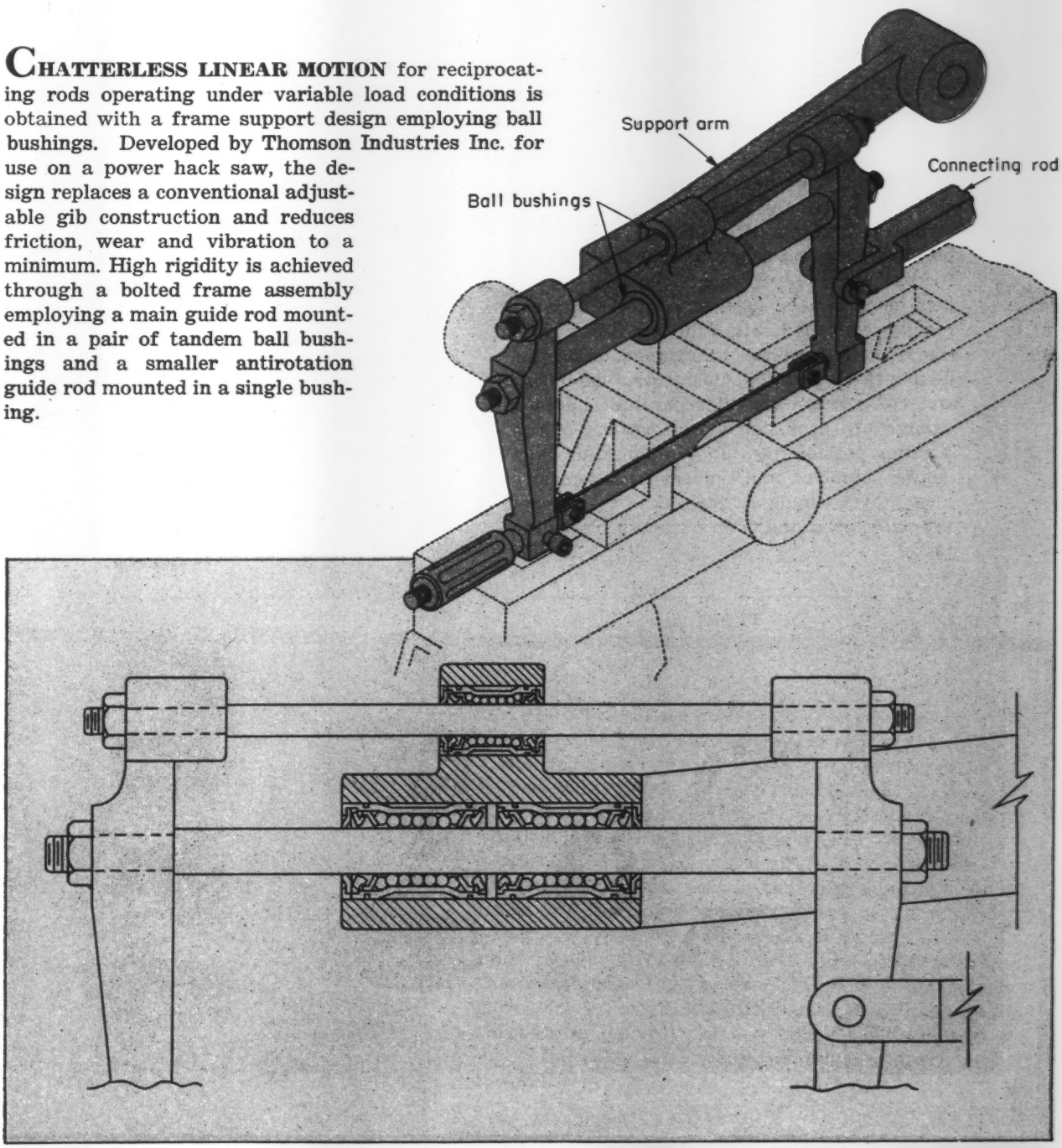
Microphotometer Designed To Minimize Operator Fatigue

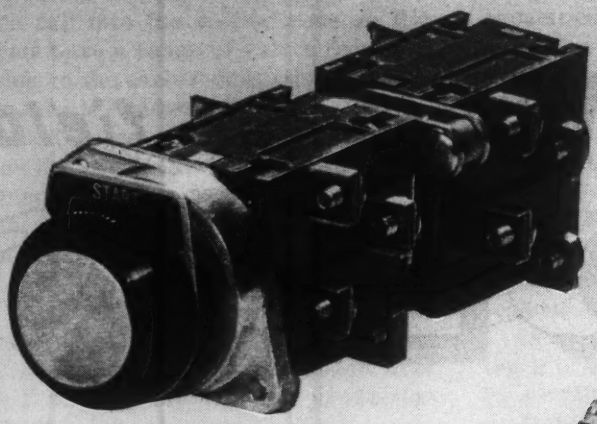
CONVENIENCE and minimum operator fatigue are two objectives attained in the design of a new Comparator-Microphotometer developed by Jarrell-Ash Co. The console model has a desk-height cabinet, and foot control for scanning motion. Panel switches are positioned on the left side, leaving the right hand free for writing and plate marking. Designed for sensitive comparison of spectroscope plates, the instrument projects an 18 by 9-millimeter area of the plate onto an 11 by 11-inch screen (15X magnification) and has a sensitivity sufficient to yield full-scale deflection for an effective slit size of 1 micron by 0.7-millimeter (700 square microns). Coarse motion control is manual, with motor-driven fine motion at a speed of 8 microns per second. Scanning period and distance are controlled by the operator with either the foot switch or pushbutton; provision is also made for returning and rescanning.

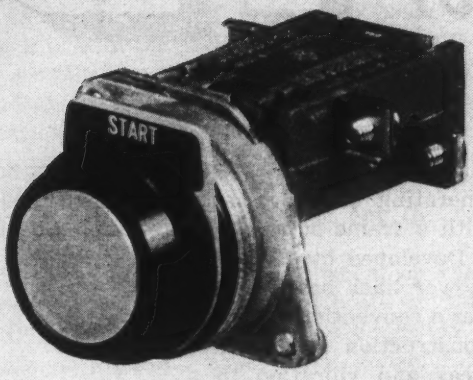


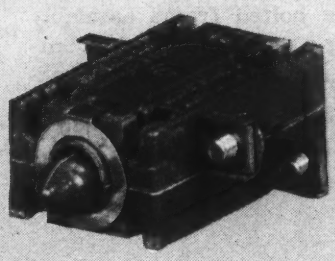
SCANNING the field for IDEAS

CHATTERLESS LINEAR MOTION for reciprocating rods operating under variable load conditions is obtained with a frame support design employing ball bushings. Developed by Thomson Industries Inc. for use on a power hack saw, the design replaces a conventional adjustable gib construction and reduces friction, wear and vibration to a minimum. High rigidity is achieved through a bolted frame assembly employing a main guide rod mounted in a pair of tandem ball bushings and a smaller antirotation guide rod mounted in a single bushing.

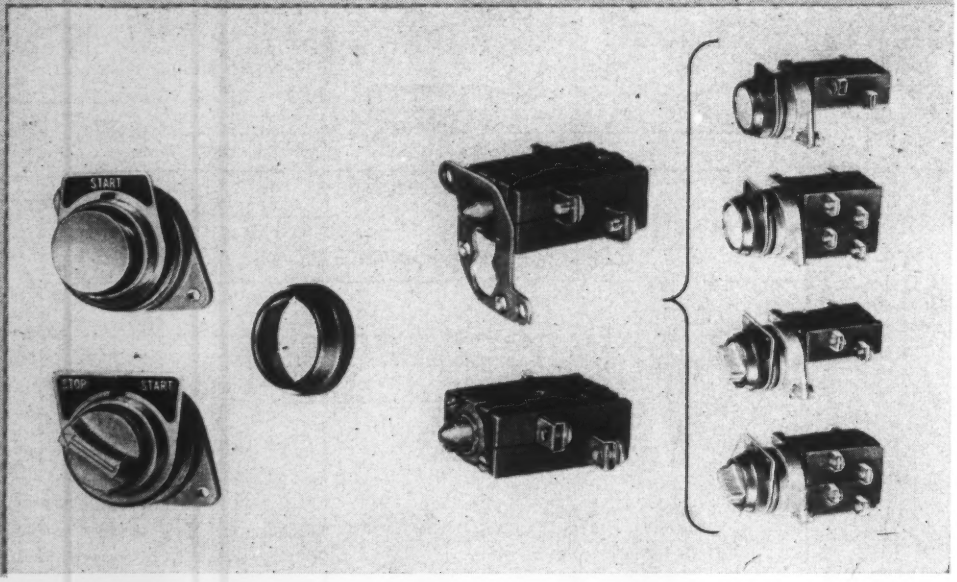




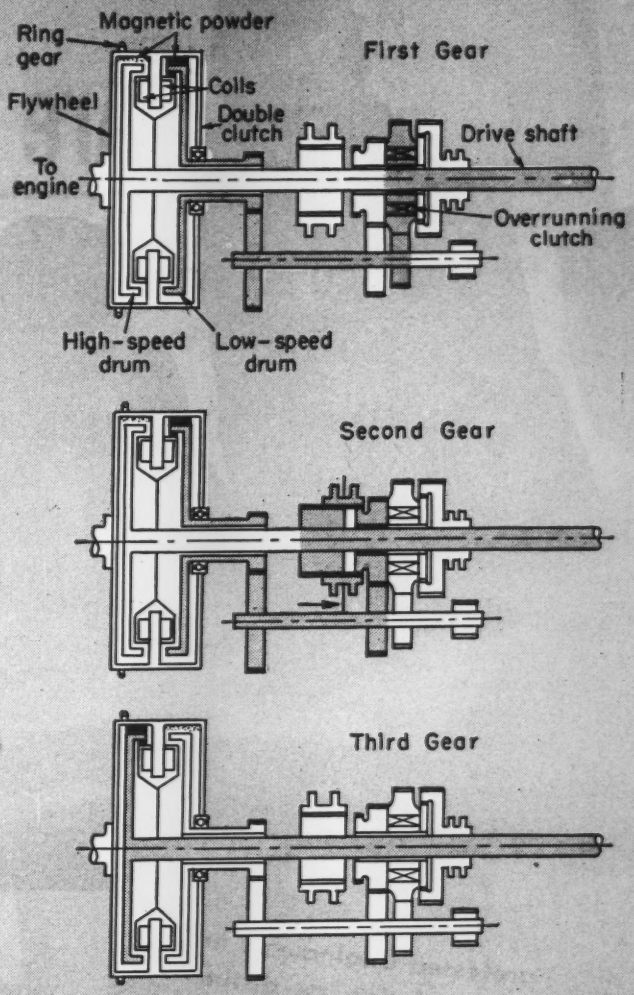


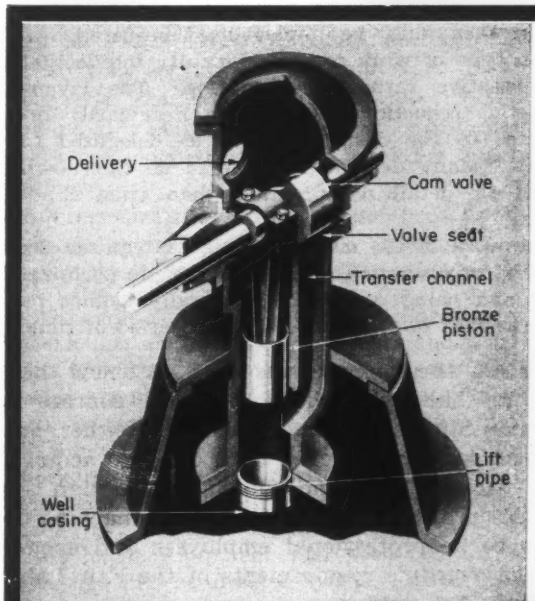


BUILDING-BLOCK construction of electrical control assemblies provides a compact oil-tight unit and offers flexibility in meeting application requirements. In a design developed by General Electric for a pushbutton construction, a standard single-pole double-throw contact block is utilized as the basic assembly element. The contact block can be used separately or can be readily combined with another block on a single mounting base to make a double-pole double-throw unit. Operators, nameplates and color rings are all separable and interchangeable, providing a wide variety of combination possibilities. In addition, four blocks can be combined in a tandem arrangement by means of a simple adapter plate to give four normally open and four normally closed contacts.



DUAL CLUTCH design developed by Eaton Mfg. Co. offers multipower performance in a single mounted unit. Alternate paths of power flow are provided by a countershaft construction employing two magnetic-particle clutches in a tandem arrangement. Engagement and disengagement of each clutch is electrically controlled; clutching action is produced by an electromagnetic coil which "freezes" a dry mixture of powdered metal and lubricant particles when energized. Application of the clutch to multispeed transmissions offers a number of automatic control possibilities. A fully automatic power shifting transmission may be readily achieved with a comparatively simple gear box. Shifting sequence is controlled by alternating from one clutch to the other; as each clutch picks up the load, the inoperative unit shifts to the next drive ratio, assuring a smooth uninterrupted transfer of power. Maintenance and wear are reduced to a minimum by the design which virtually eliminates any sliding contact between clutch members.





ROTARY CAM VALVE provides cyclic control of fluid flow and pressure in a piston pump design. Employed on a deepwell water pump developed by Gilbert Gilkes & Gordon Ltd. of Kendal, England, the valve utilizes a rotating cam, mounted to the crankshaft and resembling a conventional counterweight in appearance, which alternately covers and uncovers a delivery port in the pump housing. In operation, the delivery port is closed as the piston moves downward, compressing the water in a lift pipe. On the upstroke, the port opens and releases the pressure on the water column which instantly moves up in the lift pipe, producing a discharge through the delivery port and simultaneously opening a footvalve to draw in additional water from the well.

Are Design Engineers

By Albert Woodruff Gray
Jackson Heights, L.I.
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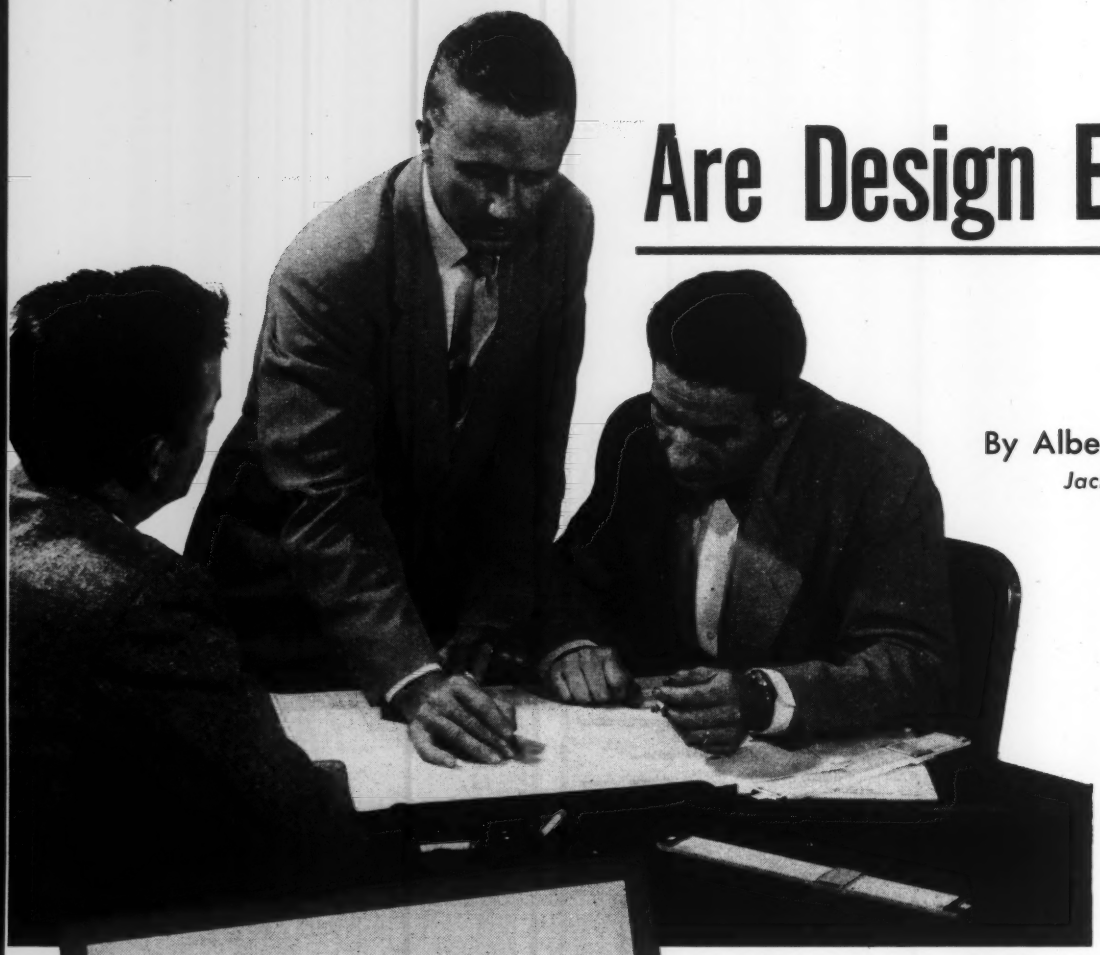


". . . professed attainments in special knowledge as distinguished from mere skill."

Photo, courtesy International Harvester Co.

TWO MACHINE designers recently brought suit against a munitions manufacturer for overtime compensation under the Fair Labor Standards Act. The defense maintained that these workers were employed in a professional capacity and as a consequence were not entitled to overtime pay under the provisions of that statute.

In relation to the right of employees to overtime compensation, the statute states that its provisions "shall not apply with respect to any employee employed in a bonafide executive, administrative, professional or local retailing capacity or in the capacity of outside salesman." The pertinent portions of the definition of "professional" under the Regulations are contained in the box on Page 113.

The work performed by these two employees was the design of machinery for the construction of 40-millimeter shells which at that time was not available in this country; each received a weekly salary of $75.00. Said the court in its characterization of this type of work in the decision of this case:

> To completely design a new machine, such as a crimping machine for shells, a machine designer must mentally conceive the kind of machine necessary for the particular work and the design then must be implemented in detail.
>
> The type of work is predominantly intellectual and creative rather than routine. The layout or detail reduction to paper is necessarily incidental to the design or may be delegated to others. Many designers prefer to do their own layout or detail work rather than trust it to others.
>
> The work of the machine designer requires the exercise of discretion or judgment in its performance and being creative it naturally cannot be standardized in relation to a given period of time.

Both of these employees had attended high school and had studied in technical courses of draftsmanship and machine design. Neither possessed an academic degree but both had acquired many years of experience in machine design.

The Federal Court in holding these machine designers to be professional employees and exempt from the overtime requirements of the Fair Labor Standards Act, said:

Professionals?

Court decisions establish their legal status in cases tried under the Fair Labor Standards Act

Fifty years ago it is probable that the employees' occupation of machine designer would not have been classed as a profession, but it is evidenced from the definition of the regulations that the scope of the term "professional" has been much broadened for the administration of the act.

We find that these employees' work comes within the regulations' definition of professional. It will be noted that the definition sets up six separate requirements. The character of the work of these employees meets each of these several tests. The work was predominantly intellectual and varied in character, required the consistent exercise of discretion and judgment in its performance, could not be standardized in relation to a given period of time, and the employees were compensated by a salary which was greatly in excess of $200 per month required in the definition.

In another suit of this character brought five years later for overtime compensation, this same defense was set up by the employer. In that instance the men were employed as electrical and mechanical designers but their work consisted merely in correcting and checking mechanical drawings.

Holding that this work was not professional employment under the overtime provisions of this statute the Federal District Court said:

> Although these employees were designated as mechanical and electrical designers and were perhaps qualified to do the work of professionals within the meaning of the Administration's definition, their functions while employed by this employer, were those of draftsmen and draftsmen checkers. The greater portion of the time worked was employed in copying lines from drawings made by various manufacturers from whom power-house equipment had been ordered or in inserting lines as directed by the engineering staff of the employer. What they did was not a creation

PROFESSIONAL DEFINED
(From the Fair Labor Standards Act)

The term employee employed in a bona fide professional capacity shall mean any employee who is engaged in work

- Predominantly intellectual and varied in character as opposed to routine mental, manual, mechanical or physical work
- Requiring the consistent exercise of discretion and judgment in its performance
- Of such a character that the output produced or the result accomplished cannot be standardized in relation to a given period of time
- Whose hours of work of the same nature as that performed by nonexempt employees do not exceed 20 per cent of the hours worked in the workweek by the nonexempt employees; provided that where such nonexempt professional work is an essential part of and necessarily incident to work of a professional nature, such essential and incidental work shall not be counted as nonexempt work
- Requiring knowledge of an advanced type in a field of science and learning customarily acquired by a prolonged course of specialized intellectual instruction and study, as distinguished from a general academic education and from an apprenticeship, and from training in the performance of routine, mental, manual and physical processes
- Predominantly original and creative in character in a recognized field of artistic endeavor as opposed to work which can be produced by a person endowed with general manual or intellectual ability and training and the result of which depends primarily on the invention, imagination or talent of the employee
- Compensated . . . on a salary or fee basis at a rate of not less than $200.00 per month.

of their imagination, skill or knowledge, but was of a routine nature.

In contrast with the decision in this case involving work in the construction of power plants is a decision made by the same court the following year. Here suit was brought against a manufacturer of fire control and navigation instruments for overtime compensation by an employee who had performed the mathematical and physical calculations as assistant to the senior engineer in the research and development of naval precision ordnance.

The court holding this employee to be a professional employee and not entitled to a recovery for overtime, said:

> There remains no doubt that he was employed as a professional engineer and performed services as such throughout the period of his employment. He selected the values of the resistors, capacitors and so on, required to make an amplifier.

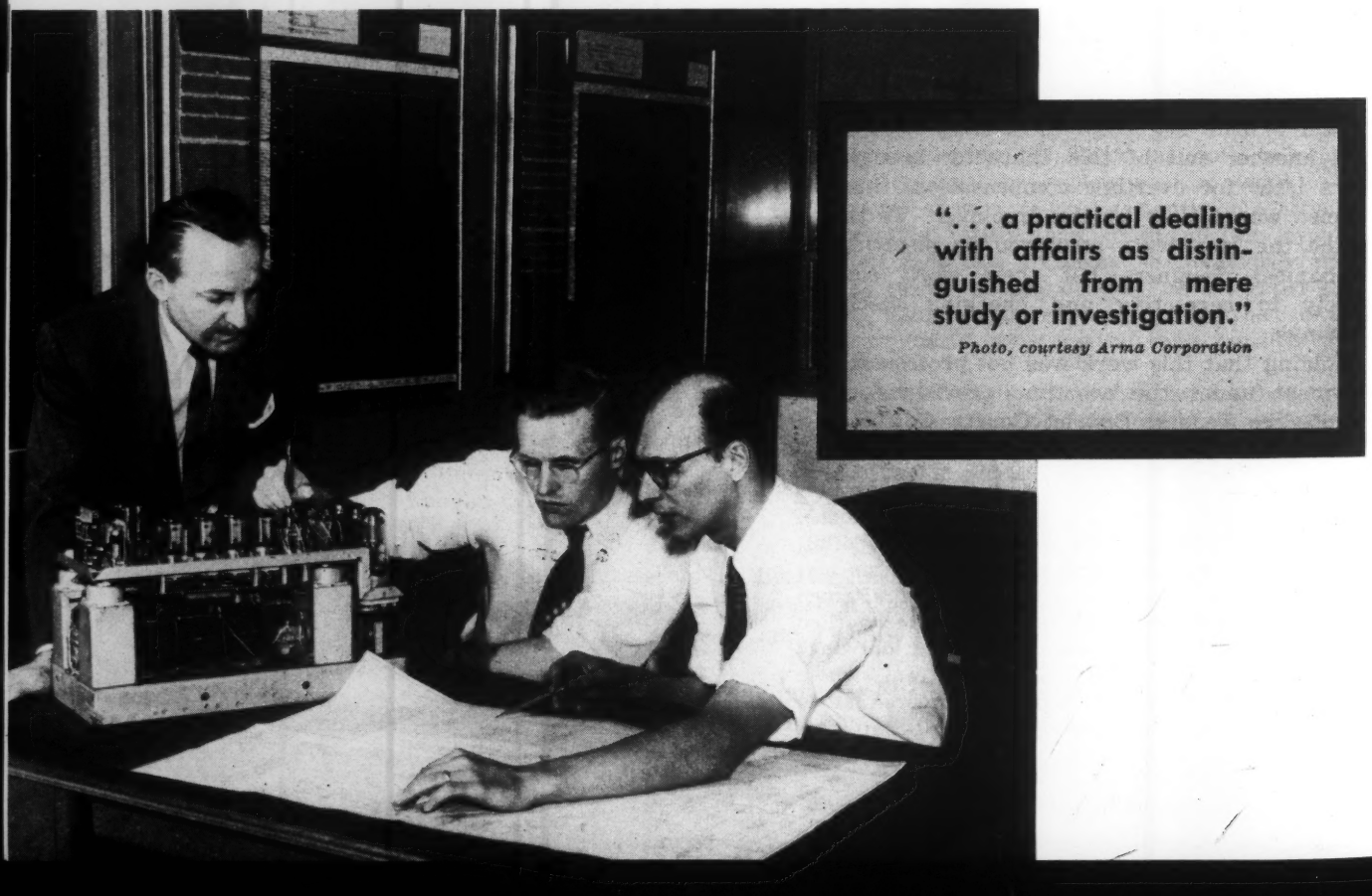
A further decision handed down by a Federal District Court a few months later, in relation to demands for overtime pay made by engineers engaged in the manufacture of electronic devices, classified these employees as professional workers exempt by the statute from overtime compensation, and stated in part:

> Their chief function, however, was to determine the most economical method of manufacture consistent with the quantity and quality desired and to specify in order the exact sequence of the operations to be performed with a designation of the tools, machines and equipment and labor classification to be used in each operation.
>
> It was their duty and responsibility to specify the material for ordering purposes and, if some tool not already available was needed, to reduce the expense of manufacture to a minimum, to describe the tool and to suggest changes in designs or tolerances where the specifications required a method of manufacture more expensive than the circumstances warranted.
>
> To do all this required a wealth of experience and knowledge of costs, an ability to discriminate between the various machines capable of doing each operation so that the one which could do the work in the desired quantity at the least expense per unit, should be selected, and a knowledge of the cost of setting up each machine in readiness for the operator.
>
> As the salary range was well above the required minimum I find that the process engineers in general were properly classified as exempt within the meaning of Wage and Hour Division's regulations.

This same controverted question occurred again only a few years ago in a lawsuit by an employee for overtime pay against a federal ordnance plant in Minnesota. The employee in this instance had, at the beginning of his employment, been a draftsman in the tool engineering department. Shortly afterward he had been assigned as an engineer specializing in gage drawing. The greater portion of his working time was devoted to the preparation of gage drawings with a general supervision of the other employees in this section.

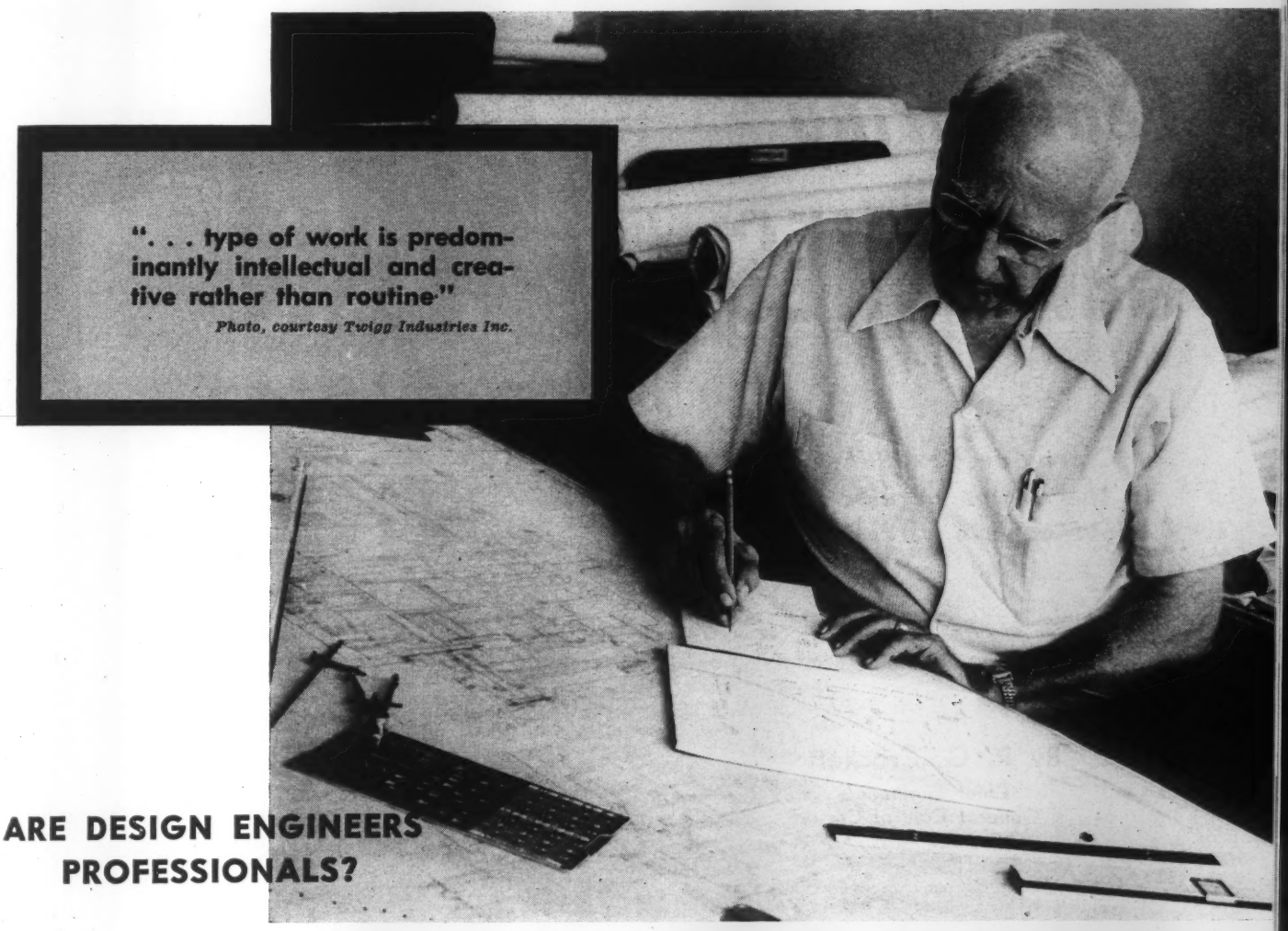
The court ruled that the work of this employee was "professional" within the meaning of the statute:

> In the case of this employee the facts warrant concluding that he qualified as an executive or a professional employee. Few are those who have attained his qualifications. Upon him the University of Minnesota conferred degrees of



". . . a practical dealing with affairs as distinguished from mere study or investigation."

Photo, courtesy Arma Corporation



ARE DESIGN ENGINEERS PROFESSIONALS?

Bachelor of Mathematics and Bachelor of Architecture, to which was added three years at the same institution devoted to chemical engineering. At different times he had four to seven draftsmen working under him. The work performed by him required original and creative ability and special training. He was skillful and efficient. Drawings completed by his group were subject to his approval and had to satisfy his judgment. To say that he did not exercise discretion and independent judgment in the performance of his duties cannot be supported. This employee has satisfied the Administration's definition of an "executive" or a "professional" employee.

A famous definition of this word "professional" was made many years ago by the Supreme Court of the United States, which fully justifies these recent decisions that a machine designer is a "professional" employee within the interpretation of that word by the Wage and Hour Division of the Fair Labor Standards Act.

At the time of this old case a Federal statute had been enacted forbidding labor contracts with aliens before their immigration to this country but excepted from its provisions "persons belonging to any recognized profession."

A contract had been made by a Louisiana sugar plantation owner with a German chemist for the employment of the chemist on the plantation. In its decision that this contract was for professional employment the court said in its definition of that term:

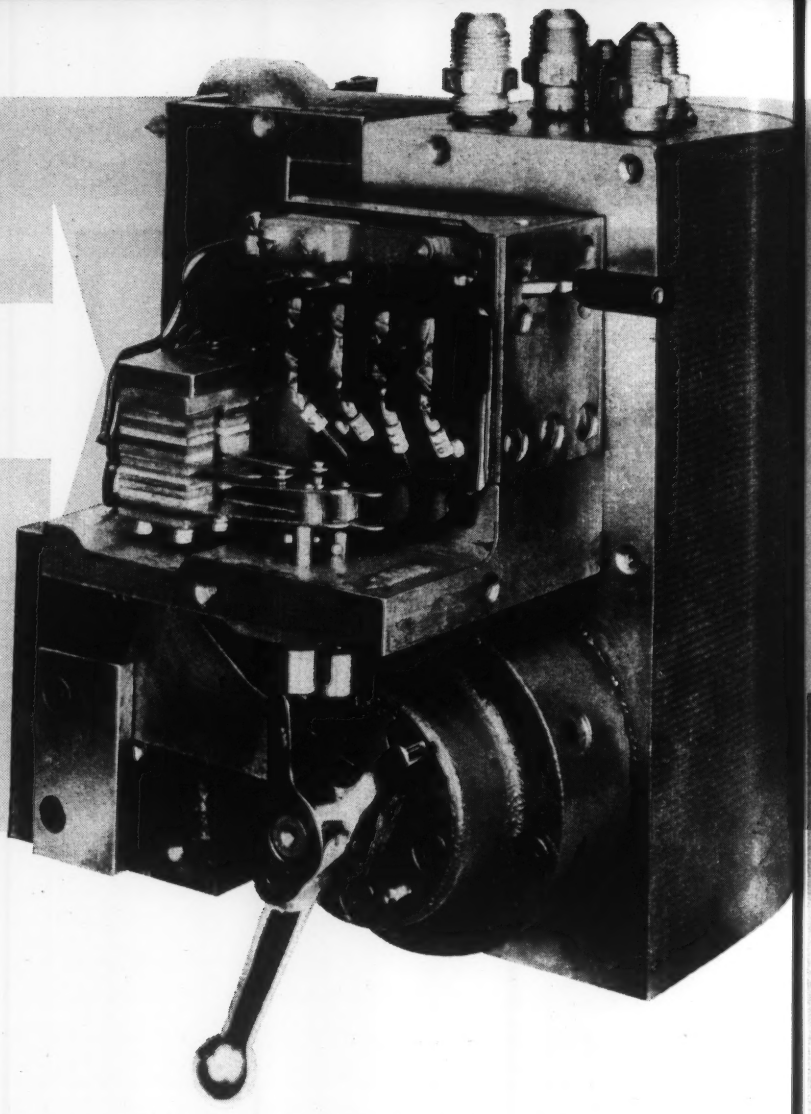
> One definition of a profession is an "employment, especially an employment requiring a learned education, as those of divinity, law or physic." Another definition of the word is "a vocation in which a professed knowledge of some department of science or learning is used in its practical application to the affairs of others, either in advising, guiding or teaching them, or in serving their interests or welfare in the practice of an art founded on it."
>
> Formerly theology, law and medicine were specifically known as the professions, but as the application of science and learning are extended to other departments of affairs, other vocations also receive the name. The word implied professed attainments in special knowledge as distinguished from mere skill. A practical dealing with affairs as distinguished from mere study or investigation; and an application of such knowledge to uses for others as a vocation, as distinguished from its pursuit for its own purposes.

REFERENCES

1. 29 U.S.C.A. sec. 213.
2. 5 Fed. Reg. 4077, sec. 541:3.
3. Aulen v. Triumph Explosive, 58 Fed. Suppl. 4.
4. Blomgren v. Gibbs & Hill, 13 C.C.H., Labor Cases, 71,816.
5. Krill v. Arma Corporation, 76 Fed. Suppl. 14.
6. Wells v. Radio Corp. of America, 77 Fed. Suppl. 964.
7. Phillips v. Federal Cartridge Corp., 69 Fed. Suppl. 522.
8. United States v. Law, 163 U.S. 258.

Leaf-Spring SWITCHES

. . . provide flexibility in the design of electrical control circuits



By R. G. Crockett
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VERSATILITY of multiple-circuit switches provides the machine designer with wide scope for the exercise of ingenuity in electrical circuit design. For instance, if full advantage is taken of this versatility the single throw of a heavy-duty lever switch can transfer as many as twenty circuits without the use of relays. Control can be effected at prearranged time intervals or in sequence, with driven switches, *Fig.* 1. Pushbutton switches can be assembled in banks to control up to 200 different, isolated circuits.

Switches which can perform these diversified functions include those using contacts mounted on leaf springs, which are discussed in this article. Such switches may be actuated manually by levers, pushbuttons or rotary knobs, or mechanically through plungers or cams, *Fig.* 1.

Switch Design: Basic element of such switches is the leaf-spring buildup, *Figs.* 2 and 3. The leaf blades are insulated from the mounting bar by spacers and quill. In *Fig.* 2 the contact blades are electrically insulated from the actuating rods by means of a Tenite or nylon lifter and an additional leaf spring. In *Fig.* 3, insulating rollers are used with the cam-lever actuator, and a lifter for the transfer to the right-hand contacts.

Leaf springs are stamped from materials which will retain adequate contact pressure and yet be capable of millions of deflections. Phosphor bronze alloys are most widely used for this purpose because of these characteristics. They are strong, good conductors, resistant to corrosion, and capable of repeated deflection. Exceptional mechanical characteristics and resistance to wear are found in beryllium copper. This material has the lowest creep of any commercial copper alloy and is used where extreme durability and long life are important.

Electrical connections to cam lever switches are made by wiring and soldering directly to the lugs on each leaf. Leaf springs are separated from each other by means of bakelite spacers as well as tubular quills which insulate buildup screws from the blades.

Contacts are made from numerous materials such as silver alloys, palladium, tungsten, and Fasaloys. Good conductivity plus resistance to wear and corrosion are prime factors in selection of this material. Contacts are usually of the silver alloy type and not infrequently are bifurcated or split. This consists of a large contact button on one spring and two smaller contacts on the tips of the other spring.

Atmospheric conditions govern the degree of fungus proofing and anticorrosive plating on switch parts. One factor commonly overlooked is the reaction of dissimilar metals in the presence of an electrolyte, for instance, salt atmosphere. Even though protective plating is applied to *individual*

Fig. 1—Left—Control assembly for machine tool, showing lever switch (upper) and cam-actuated leaf spring buildups (lower) for chuck operation and interlocking

Photo, courtesy The Bollard Co.

Fig. 2—Right—Basic leaf-spring buildup used in multiple-circuit switch assemblies. Design shown is form A, Table 1, which is normally open

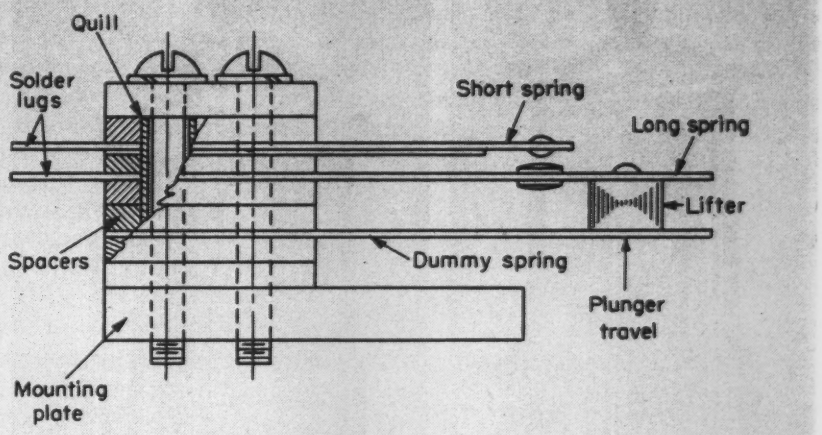
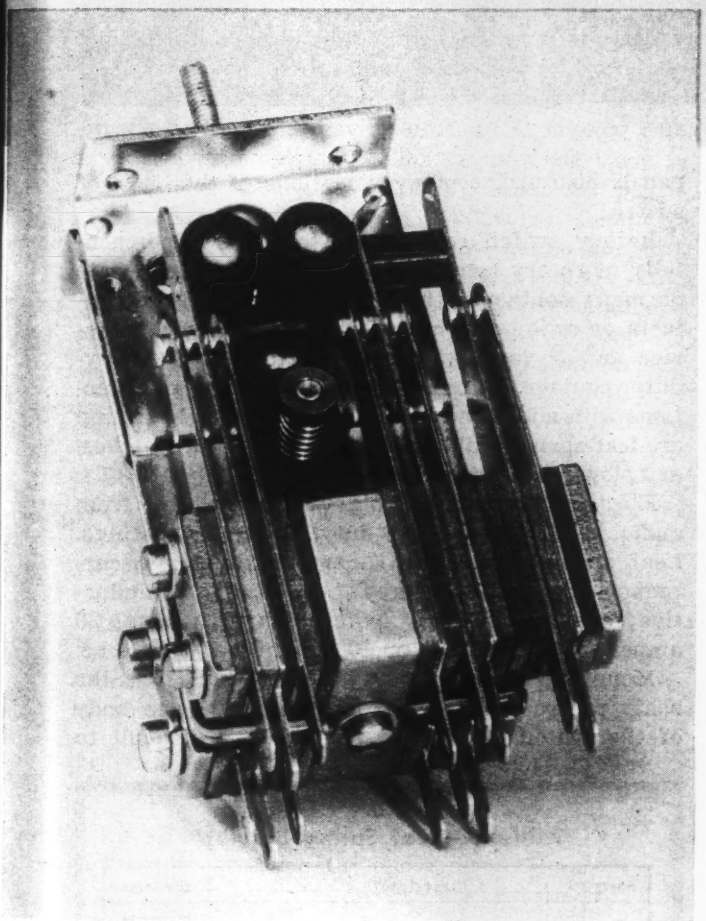


Fig. 3 — Below — Assembly of leaf-spring buildups in a cam-lever switch controlling five individual circuits



parts, the possibility of corrosion is present if a break in the plated surface allows moisture penetration, resulting in electrolytic action.

Eight different forms of leaf-spring buildups are available, *Table* 1. It is common practice to use combinations or multiples of these, acording to circuit control requirements. There is, of course, a mechanical limitation to the number of buildups per switch frame since excessive spring pressure will naturally result in stiff operation. It is possible to mount up to four sets of transfer contacts (form C) in each position.

Switch assemblies are conveniently classified in five groups according to method of actuation:

Manual: Lever switches
Pushbutton switches
Rotary switches

Driven: Rotary switches
Plunger or cam-operated buildups

Lever switches, *Figs.* 3 and 4, find many applications in both industrial and commercial testing equipment. They are capable of handling currents up to 10 amperes, 115 volts ac noninductive. Mounting is accomplished either by use of mounting screws, *Fig.* 4, or "single-hole mount" in which the neck of the switch is threaded and protrudes through the panel, *Fig.* 5. This is held in place by a large nut and lock washer.

The lever is usually provided with an insulated handle and is commercially available in several lever throw combinations of lock, nonlock, full throw, and half throw, *Table* 2. In some instances lever switches have been paired with a common mechanical linkage by both lever handles so that they may be actuated simultaneously. Solenoid-operated cam lever switches are convenient for remote locations. The cam lever switch in *Fig.* 5 has four transfer positions and one neutral posi-

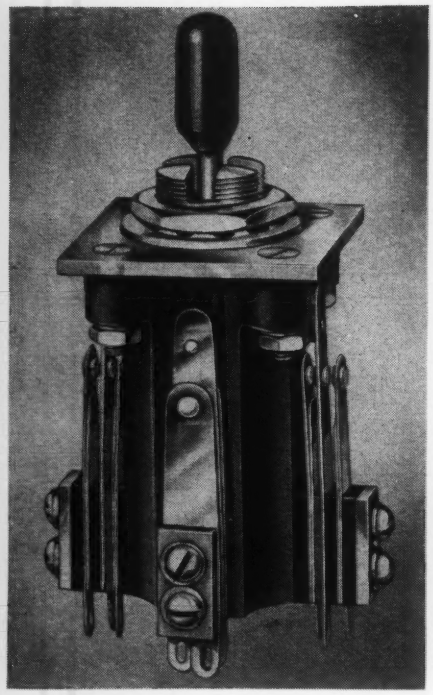


Fig. 4—Extreme left—Simple cam-lever switch containing leaf-spring buildups

Fig. 5 — Left — Four-way cam lever switch with handle simulating up-down-left-right type of control motion. Switch is single-hole mount type

tion, simulating an up-down-left-right aircraft pilot control which is often useful as a positioning control for cranes or load equipment.

Pushbutton switches of the multileaf type permit control of several circuits through a single actuation of a pushbutton, *Fig.* 6. Practical applications of this type of switch include information selection, quality testing, and equipment sequence control. Pushbutton switches are rated at 5 amperes, 115 volts ac noninductive. The plungers (to which are attached pushbuttons) operate against the leaf springs through an insulator and lift them to perform the necessary contact transfer. As many as fifteen pushbuttons may be placed in a single row, each with interconnecting mechanism so that a variation of switching action is possible.

Pushbutton operation may be any of several types:

Nonlock—has no locking action and returns to normal position on release of finger pressure

Accumulative lock—buttons pushed in remain locked in position until released by pushing reset button

Lock release—any button pushed in releases any previously pushed in button

No two interlock—only one button can be pushed in at one time, and that releases any other button.

In addition, single rows of buttons can be intercoupled so that depressing a button in one row will release all previously engaged buttons in any other rows. Such an array of pushbuttons can control approximately 200 individual circuits.

Manually operated rotary switches are employed in many industrial and home appliances in one form or another. Test instruments and control panels also utilize many variations of this type of switch.

Rotary switch construction consists fundamentally of rotary cams or switch arms which actuate or make contact with a surrounding ring of contacts or switches. The switches used in such a device are of various types and range from heavy-duty contact buttons to low-current wafer sections with slide contacts. Included within this group are leaf-spring buildups, snap action limit switches, and slow-make limit switches.

Electrical ratings on rotary switches vary from audio currents to heavy-duty power tap ratings. Leaf springs, when used, carry a maximum current rating of 10 amperes, 115 volts ac noninductive; snap-action limit switches carry a usual 20 amperes, 115 volts ac, or 10 amperes, 230 volts ac.

Mounting of rotary switches is such that the shaft protrudes through the panel with the body of the switch behind the panel. It is difficult to

Table 1—Leaf Spring Buildups

Form	Description	Contacts
A	Normally open	
B	Normally closed	
C	One side normally closed (SPDT)	
D	Make before break	
E	Break-make before break	
F	Both sides normally open (SPDT)	
G	Both sides normally closed (SPDT)	
H	Make-make	

state a maximum number of circuit possibilities since the light-duty rotary switches combine many low-current circuits on a small frame. For instance, a six-gang wafer radio switch may have as many as twelve poles and six positions per gang. A heavy duty tap switch may consist of fifteen or twenty taps depending on physical size and arrangement.

Driven rotary switches in combination with a driving element provide the all-important means of performing timed operations automatically. In general, two systems are employed: 1. The switch rotor may be indexed mechanically upon completion of the previous cycle; and 2. The switch rotor may be driven at a predetermined rate by a timing motor, or coupled shaft, so that contact transfer occurs at definite time intervals.

Electrical ratings vary with the type of switches used, and the ratings of commercially available products cover a wide field. Construction of rotary driven switches is similar to that of the manually operated type except that provision is made for coupling to a driving element. Frequently a combination of both a driving unit and a manual control knob is employed. This permits the cycle to be jumped ahead, as in many home automatic washing machines. This combination type employs a ratchet clutch which provides enough coupling for indexing through spring tension from the driving arm, and at the same time allows manual disengagement for changing to a new clutch position.

A solenoid-driven rotary switch is shown in *Fig.* 7. Here both cams and switches are preset to perform specific contact transfers upon each actuation of the solenoid.

Switch timing may be either preset or adjustable. An adjustable arrangement is most necessary on machine tool control applications where either major changes in timing and switching or fractional corections to an established cycle must be made.

Duration and frequency of contact transfer may be controlled by several methods. Variables may be introduced into: *a*. Rotary speed, *b*. Location of cam, or *c*. Location of switches. Varying the shaft speed of a rotary switch will, of course, vary switch timing. This may be accomplished by a change in machine speed or gear ratio on the coupling shaft.

Flexibility in timing can be accomplished also by varying the cam location on a 360-degree periphery. Thus, split cams are used to adjust

LEAF-SPRING SWITCHES

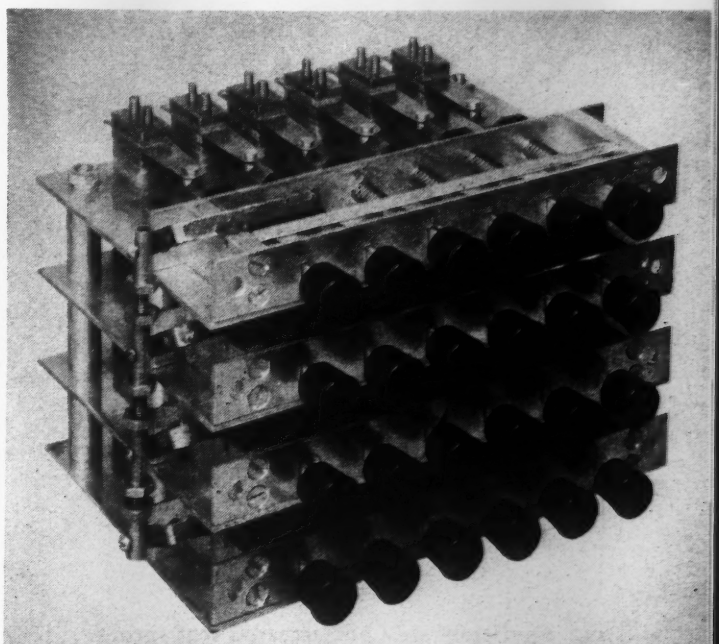


Fig. 6 — Above — Bank of pushbutton switches. Actuating mechanism provides a variety of interlocks in such assemblies

Fig. 7 — Below — Solenoid-actuated rotary switch for controlling multiple circuits

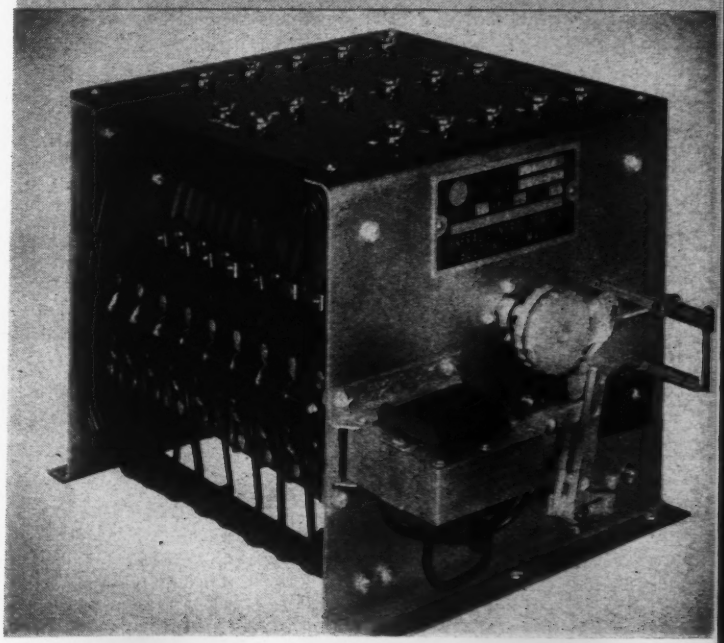


Table 2—Switch Lever Operation

Symbol	
Lock (stays put)	Non-Lock (spring return)
Three-Position	
Two-Position half throw	Two-Position full throw

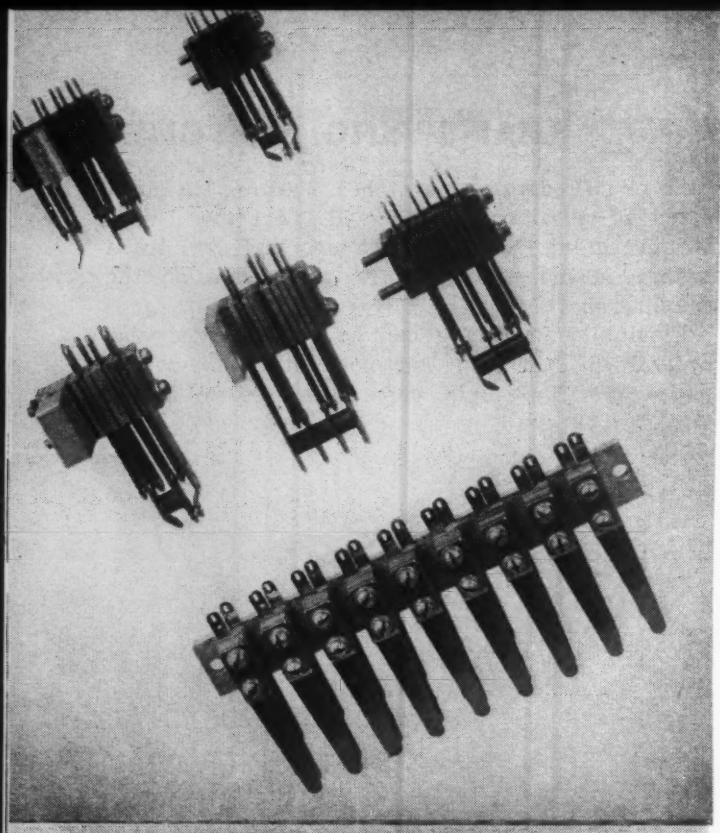
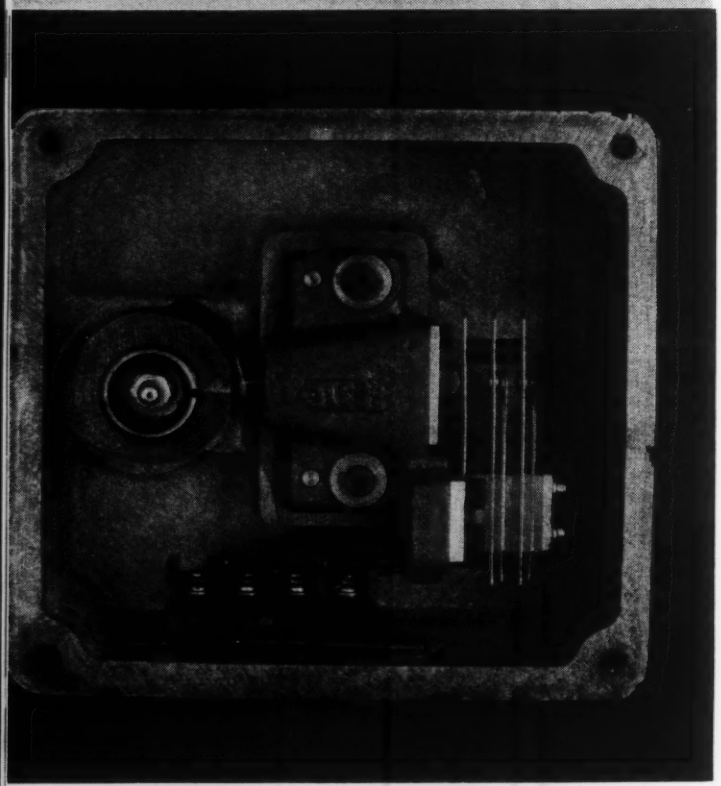


Fig. 8—Above—Typical arrangements of leaf-spring buildups for mechanical actuation by plungers or cams. Upper switches include provision for transfer of motion from one set of contacts to another

Fig. 9—Below — Cam actuated leaf-spring buildup switches controlling index-holding of side head turret in a machine tool

Photo, courtesy The Bullard Co.



LEAF-SPRING SWITCHES

the position of cam shoulders; detachable cam shoulder rings are also employed. However, both of these require more than simple shop knowledge to adjust and therefore are not too practical from a maintenance viewpoint.

Simplest of the methods is the change of switch location, and when this is done from the outside of the enclosure, no parts need be removed. Limit switches are mounted in slots by set screws and adjustable either in a radial direction or, in other cases, transverse direction. With fixed cams, radial adjustment varies the switching with respect to zero degrees of shaft rotation. Transverse adjustment permits setting of the *duration* of switching when used with a wide cam with spiral shoulder.

The combinations of both cam positioning and variable switch location offer an even wider range of settings; usually, however, this degree of flexibility is not necessary.

Spring leaf blades offer many possibilities for multiple-circuit rotary switch control. In addition to the variety of switching combinations of form A through form H buildups, *Table* 1, at any one position, multiples of these may also be mounted either at separate points around the cams or mounted against separate cams to form a truly multiple circuit switch.

Plunger or cam-actuated leaf spring buildups are utilized in obtaining fully automatic operation of machine tools and other equipment, *Fig.* 1. As shown in *Fig.* 8, these consist of bars upon which are mounted a number of leaf-spring buildups. Each buildup is actuated by a mechanical plunger or cam, and sequence of actuation determined by plunger timing. Contact ratings are usually 10 amperes, 115 volts ac noninductive, this being sufficient capacity for control relays and auxiliary electrical control equipment.

Leaf spring assemblies are located in an enclosed section of the machine housing to eliminate the effects of dust, chips, and oil.

Cam-actuated leaf contacts can provide multicircuit control at prearranged time intervals, *Fig.* 9 thus eliminating the need for bulky mechanical linkage. Such an arrangement offers certain advantages of economy and space over timer-relay combinations. The switches are compactly designed to occupy a minimum of space and their construction insures long life and reliable operation.

"We must be careful to avoid what might be called power myopia—the popular current assumption that peacetime atomic energy means only nuclear electric power. Remember how often, in the past, we have been smothered by the obvious. Even now we may be looking right at some uses for atomic energy of tremendous significance and not seeing them."—THOMAS E. MURRAY, *commissioner, U. S. Atomic Energy Commission.*

Line-of-action analysis leads to optimum geometry and practical tolerances for precision

GEAR TOOTH ACTION

By Axel H. Ahlberg
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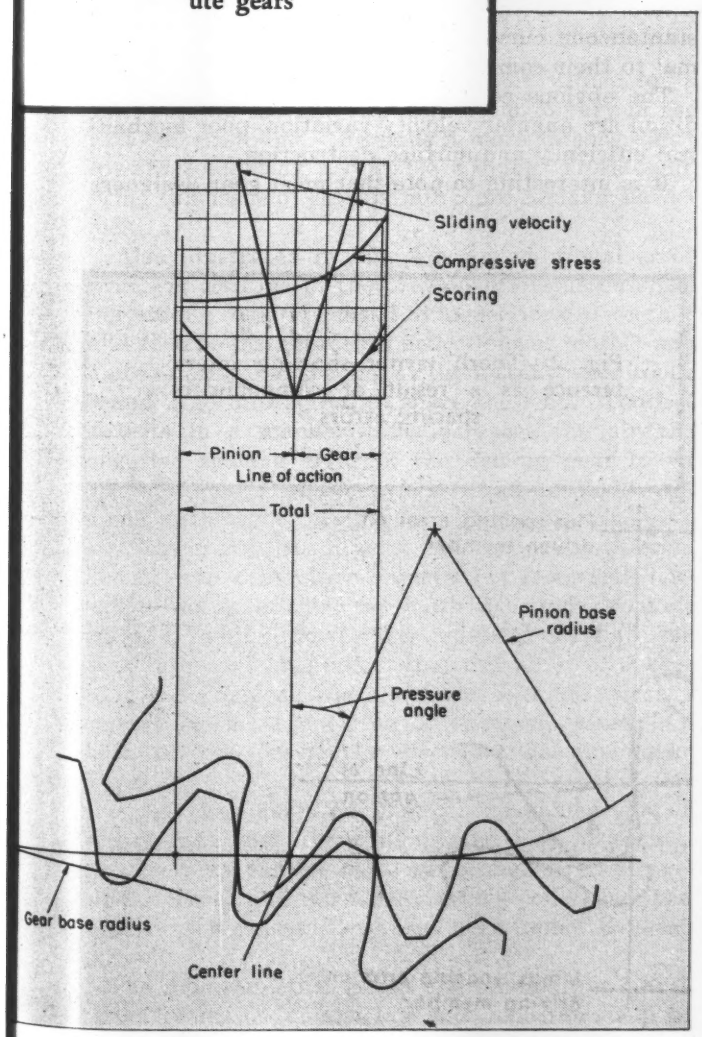


Fig. 1 — Stress chart and line of action diagram with superposed tooth layout for a pair of mating involute gears

ANALYSIS on the line of action of mating gear teeth may often reveal the best gear tooth geometry as well as dimensional corrections that can be made to insure proper operation. Recent results obtained with aircraft, electronic, instrument and other precision gear applications have indicated that gear tooth errors along the line of action have been responsible for many failures. In many cases, these failures may be attributed to a lack of appreciation of just what constitutes a destructive gear tooth error. A line-of-action analysis focuses attention on the pitfalls and often leads to judicious countermeasures.

Preliminary Steps: To obtain a complete picture of gear action, analysis should begin with a layout, to some convenient scale (a diametral pitch of 1 is frequently used), of the line of action of the gears. The dimensions needed for this layout are the center distance and base diameters of the gears. From these data, the base circles are constructed and a line is drawn tangent to both circles and intersecting the center line. This line represents the line of action and is the path along which all involute tooth contacts should occur if uniform angular velocity is to be transmitted from the driving to driven gear.

The next preliminary step is to make a tooth layout for each gear member. This should include an analytical or graphical development of the in-

volute tooth curves, plotted in the same scale as the line of action layout. At least three or four teeth of each gear should be constructed, using circular pitch and tooth thickness to mark off tooth positions. The final tooth layouts should ideally be in the form of cutouts made from some type of transparent plastic material and including centers to permit turning.

The two layouts, in combination, offer a useful tool in design analysis. Geometric meshing conditions for mating gears may be readily simulated by superposing the gear tooth layout over the line of action diagram, *Fig.* 1. Fundamental concepts such as first point of contact, backlash, contact ratio and pure interference can thus be studied. However, for the majority of cases, these basic factors will usually have been determined previous to the tooth layout construction. The primary purpose of this article is to demonstrate how these layouts can be utilized to interpret the effects of, and need for, dimensional tolerances of given magnitude for mating gear teeth.

Sources of Error: Some of the more significant gear errors, measurable or appreciable, are:

1. *Spacing error,* the tooth-to-tooth error measured along the line of action between adjacent teeth.
2. *Involute error,* the plus or minus deviation from a true involute curve that is generated from the circumference of the base diameters.
3. *Runout,* the difference in radial location of tooth profiles with respect to their functional centers.
4. *Method of gear support,* a matter of design arrangement.

Spacing Error: The effective error of spacing is found only if measured along the line of action. Its numerical value should be recorded as a plus or minus deviation from absolute spacing accuracy.

After these values are known or assumed, pending fabrication of parts, the spacing error combination that has the most detrimental effect on line of action may be readily determined. From *Fig.* 2, it can be seen that this greatest error exists when two pairs of teeth begin engagement with the largest existing negative spacing error on the driver meeting the maximum positive spacing error of the driven member. In this condition of mesh, due to the combined spacing errors, tooth 3 will come into action prematurely. Its first approach action, relative to tooth 2, will occur outside the line of action, producing an "out-of-phase" engagement and causing a disturbance of angular velocity transmission. Furthermore, the first approach action of tooth 3 will be with the sharp corner of the tip-land portion as the leading edge, tending to scrape or cut the lower flank portion of its mate until it is back in phase with the line of action, and from then on acting correctly with instantaneous curves parallel to each other or normal to their common tangent.

The obvious consequences of the foregoing condition are angular velocity variation, poor mechanical efficiency and surface destruction.

It is interesting to note that most gear designers

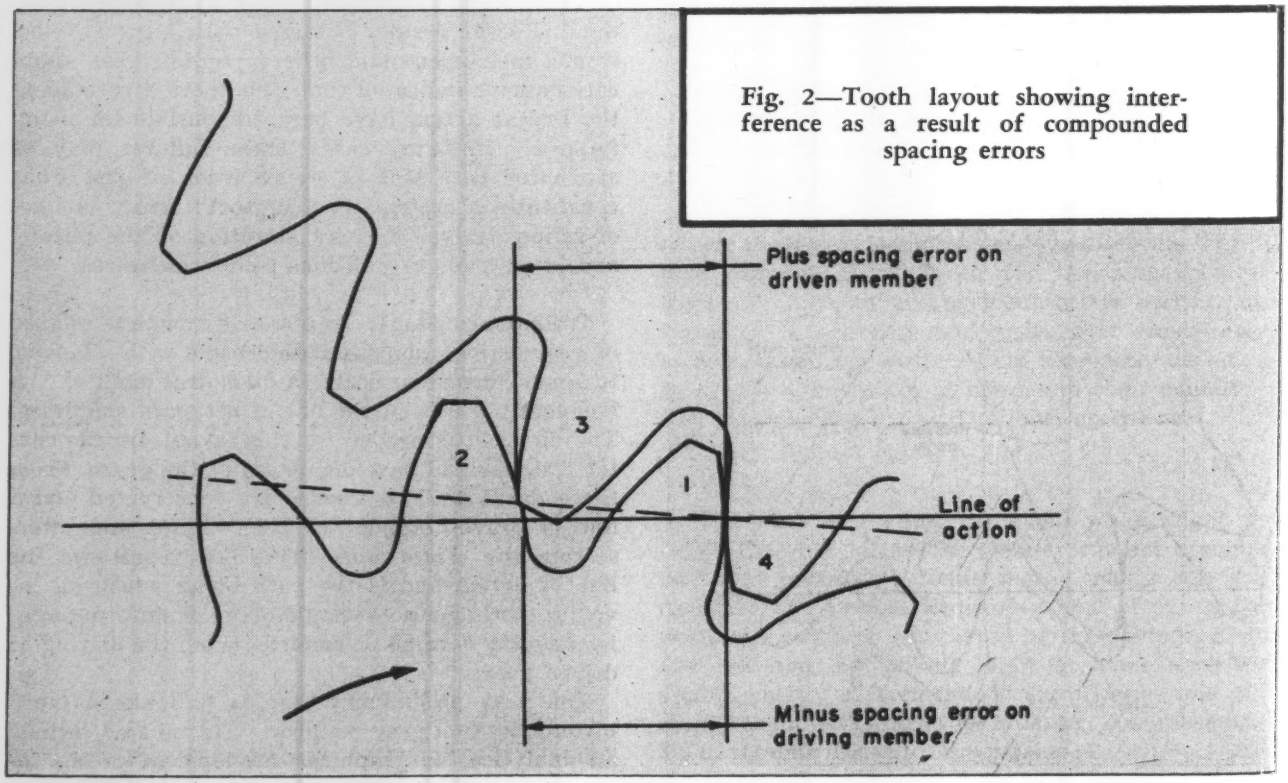


Fig. 2—Tooth layout showing interference as a result of compounded spacing errors

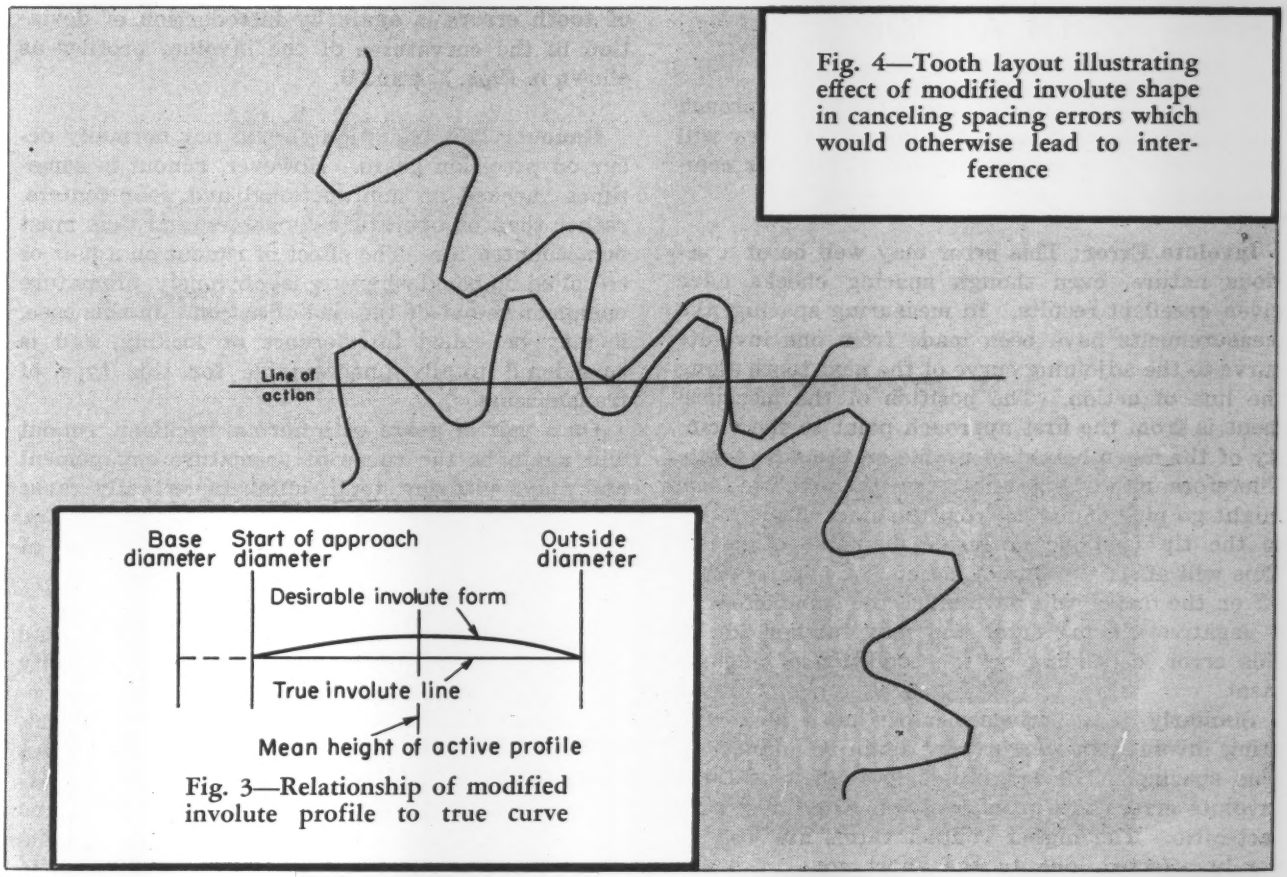


Fig. 3—Relationship of modified involute profile to true curve

Fig. 4—Tooth layout illustrating effect of modified involute shape in canceling spacing errors which would otherwise lead to interference

are in wide discord about allowable values for a gear scoring factor. Numbers seem to vary in the ratio of six-to-one. Perhaps a more intense effort toward comparing acceptable spacing errors could bring this issue of scoring into more common agreement.

Also illustrated in *Fig.* 2 is an additional error which is additive to the previously discussed spacing error. This is caused by deflections of teeth 1 and 4. The instantaneous deflections of tooth 1 and 4 are effective on spacing at the instant when tooth 3 and 2 go into action to share the load. Tooth 1 deflects in a manner that increases the already negative spacing error of the driving gear to an even greater negative value. And tooth 4 acts much in the same manner, but it increases the plus spacing in the driven gear. The amount of active deflection is difficult to observe, but it nevertheless exists and is affected by tooth geometry, contact ratio, pitch-line load, and material strength or structure. It is important that this effect of deflection be recognized and allowance be made for cancelling the induced errors of operation caused by both of the previously discussed absolute gear errors.

It may be pointed out that other combinations of errors may also occur along the line of action. However, as far as basic gear geometry, dimensional errors and normal loads are concerned, the conditions discussed here have been found the most serious.

The most effective means for elimination of destructive action of spacing and deflection will be realized if control is exercised over deviation in the curvatures of involute profiles.

This deviation should be in the form of a maximum-plus condition at the mean height of the active tooth profile, gradually returning to true curvature at the tip and lower tooth flank, *Fig.* 3. The amount of this plus deviation should be in the order of equal to or greater than the effective spacing and deflection errors.

The effect of involute deviation upon the line of action spacing errors is shown in *Fig.* 4. The plus deviation on the driving gear will cancel its own inherent negative spacing and the plus deviation on the driven gear will cancel its own positive spacing error. This somewhat amazing result is, of course, due to the directions from a fixed point of the applied deviations. It may be further stated that a new operational pitch has been established.

To affirm the concept that the worst condition of effective errors along the line of action has been analyzed, it will be helpful to assume the exact opposite values of spacing errors for the driving and driven gears. Under these conditions, it will be found there is a slight reduction in the active portion of the line of action and a subsequent reduction in contact-ratio. This will not be harmful unless the contact ratio is so small that it will cause a lack of overlap action and thus give an effect of jumping from tooth to tooth. With contact ratios of 1.3 or larger, and controlled deviation, the previously suggested method of tooth form is fully justified for precision gears. Also, the cutting action of the diamond shaped top land

of the tooth is eliminated. Since the first approach action is somewhat delayed, involute curves will make contact, as should be, normal to their common tangent.

Involute Error: This error may well be of a serious nature, even though spacing checks have given excellent results. In measuring spacing, the measurements have been made from one involute curve to the adjoining curve of the next tooth along the line of action. The position of the measurement is from the first approach point to the vicinity of the mean height of profile on the next tooth. Therefore, it can be assumed that the involute form might go plus or minus from the start of approach to the tip (outside or inside diameter of gear). This will affect the line of action. A negative fall-off on the driver will have much the same effect as a negative spacing error and may further add to this error, depending on the condition of engagement.

Similarly, if the driven member has a plus deviating involute, this error may again be additive to plus spacing. The magnitude and effect of these involute errors are intimately connected with contact-ratio. The higher contact ratios are less severely affected, due to the short zone of single tooth contact, *Fig.* 5. The best means for control of tooth errors is again by introduction of deviation in the curvatures of the involute profiles as shown in *Figs.* 3, 4 and 6.

Runout: This condition should not normally occur on precision gears. However, runout is sometimes checked on nonfunctional and poor centers, rather than on operating diameters, and thus must be accounted for. The effect of runout on a pair of so-called no-backlash gears is, obviously, premature engagement out of the line of action. In this case, it may be called interference or locking, and is considered totally unacceptable for this type of transmission.

On a pair of gears with normal backlash, runout will again be the cause of premature engagement and may, with low tooth numbers, actually cause interference. Here again, involute deviation, *Fig.* 3, can cancel some of the poor effects of runout of tooth profiles.

Method of Gear Support: Briefly, it may be said that the gear designer should exercise his ingenuity to achieve a design that provides for a full line contact along the face of the gears. This, of course, is for parallel-axes gearing only. The means for accomplishing this includes straddle mounted bearings and parallel bores. Over-hung mountings and tapered tooth faces are not usually acceptable because skewed tooth profiles are not consistent with the basic concept of precision gearing.

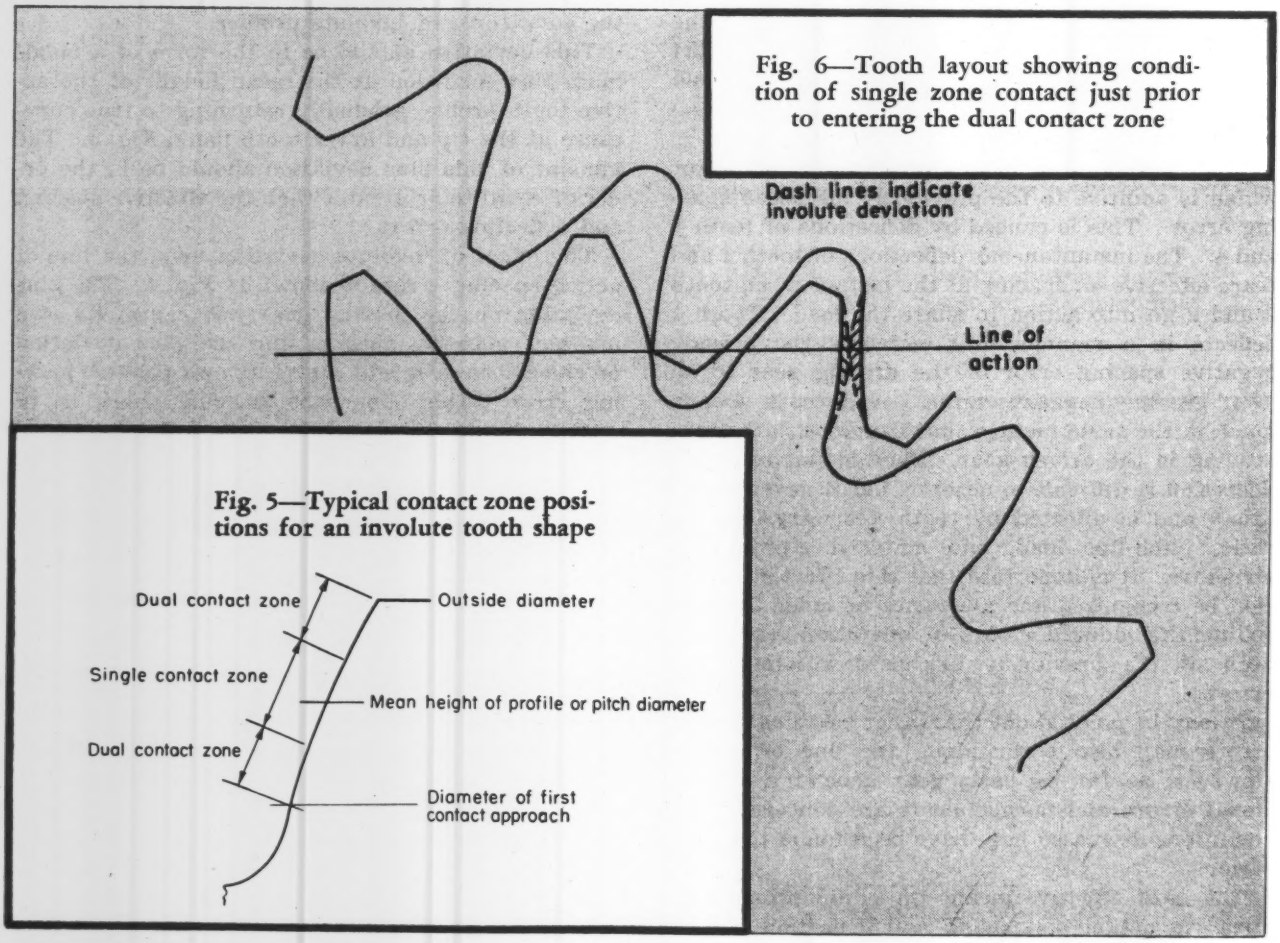


Fig. 6—Tooth layout showing condition of single zone contact just prior to entering the dual contact zone

Fig. 5—Typical contact zone positions for an involute tooth shape

High strength
Electrical properties
Chemical resistance

are chief design advantages of . . .

EPOXY LOW-PRESSURE LAMINATES

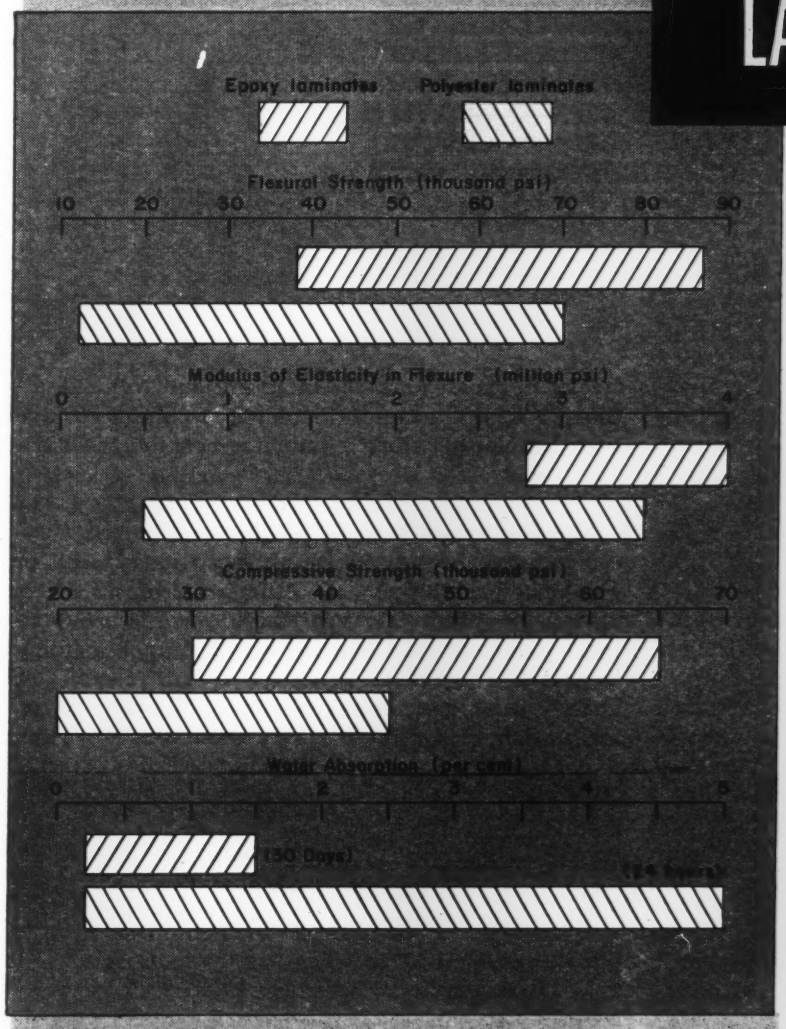


Fig. 1—Comparative properties of epoxy and polyester glass cloth low-pressure laminates

IN A FIELD long dominated by polyester plastics, epoxy low-pressure laminates have recently made some striking advances, and can be considered the chief contender for the championship title. Possessing several unique design advantages, laminated epoxies have passed through their "trial" period and are now being used in practical commercial applications.

Main delay in development of epoxy resins as plastics for low-pressure laminating has been the concentration of development work in three other major areas: as high-strength adhesives, as potting and casting resins, and as base resins for durable coatings. Now firmly established in these fields, epoxies

Data for this article, based on Epon epoxy resins, courtesy Shell Chemical Corp.

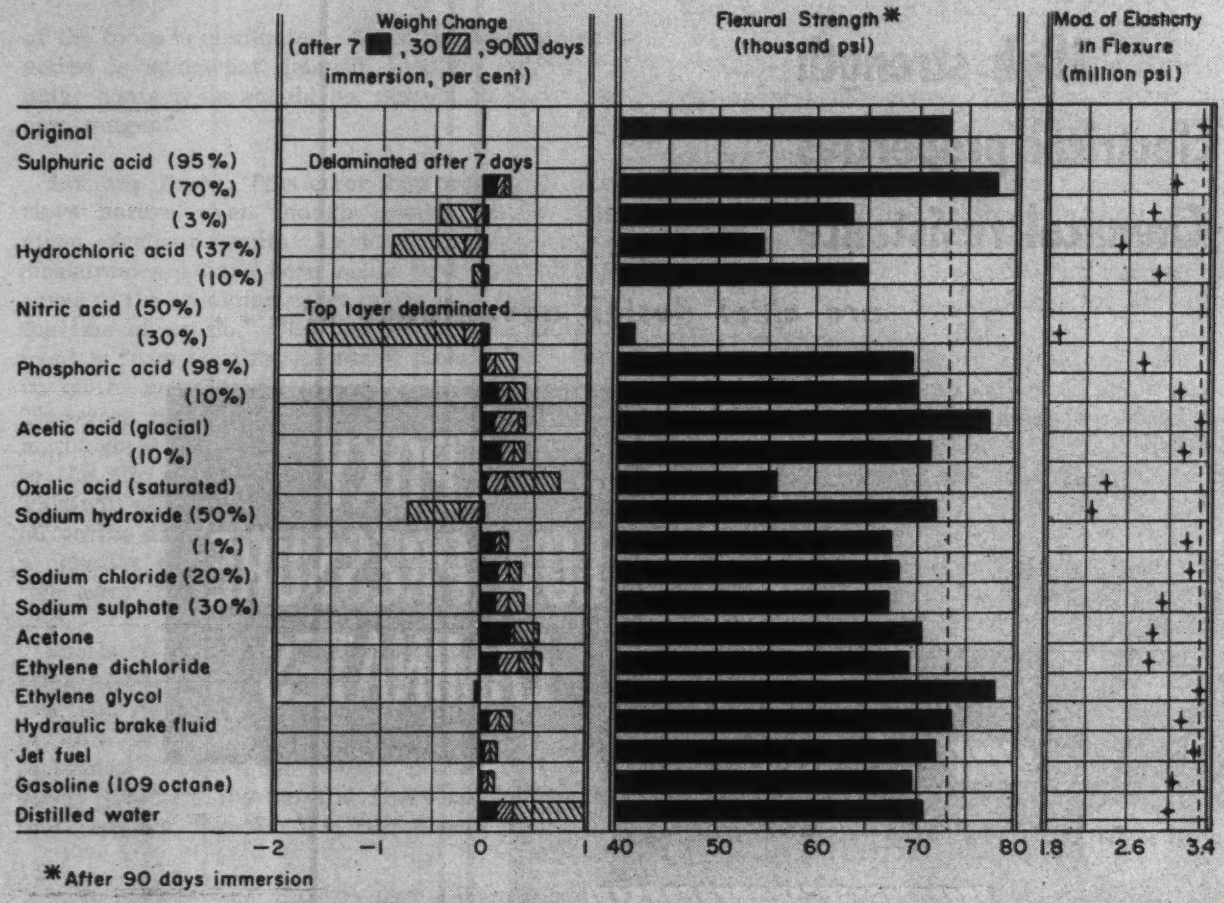


Fig. 2—Chemical resistance of epoxy glass cloth laminates

will undoubtedly receive more concerted attention as laminating plastics. And expanded facilities for production of the resin, such as Shell Chemical Corp.'s new plant in Houston, Tex., which has tripled production of their Epon resins, have assured an ample supply to meet future needs.

Advantages and Disadvantages: One of the chief advantages of epoxy low-pressure laminates is their high strength, *Fig.* 1. Epoxies have exceptionally high adhesive strength, giving a good bond between the plastic and base material. Thus, epoxy glass fiber laminates are logical materials for high-strength structural low-pressure laminates.

In some cases—particularly with alkalies—epoxy laminates have better chemical resistance than the polyesters, *Fig.* 2. Moisture resistance is excellent and absorption low. Electrical characteristics of glass-reinforced types are at least equivalent to those of polyesters, *Table* 1. Maximum service temperature is about the same—approximately 350 F — for intermittent exposure of high-strength types, and strength retention at high temperatures is good, *Table* 2.

To offset these advantages, however, epoxies are higher priced at present, although this factor could conceivably change with larger volume use. And because of the very adhesion that results in higher strength, epoxies may be more difficult to mold, although again adequate molding techniques have been developed which eliminate most of the difficulties.

Manufacturing Methods: Epoxies, like the polyesters, have been used mainly with glass cloth or glass fiber reinforcement, although Orlon fabric is also being used. Conventional low-pressure laminating techniques—bag molding, contact molding or matched metal die molding—are all feasible.

Two basic procedures are possible—wet layup lamination using liquid resins or dry layup using

Table 1—Typical Electrical Characteristics*

Surface resistivity at 500 v (ohm)	3.22×10^{13}
Dielectric constant at 1000 cycles	5.65
1 megacycle	5.26
100 megacycles	5.08
Power factor at 1000 cycles	0.017
1 megacycle, dry	0.018
1 megacycle, D 24/23	0.021
100 megacycles	0.39

*Epoxy resin and glass cloth "Epoglas" laminates.

Fig. 3—Above—Air storage tank for jet aircraft starting system fabricated by Apex Electrical Mfg. Co. from one continuously wound strand of Epon epoxy-impregnated glass fiber

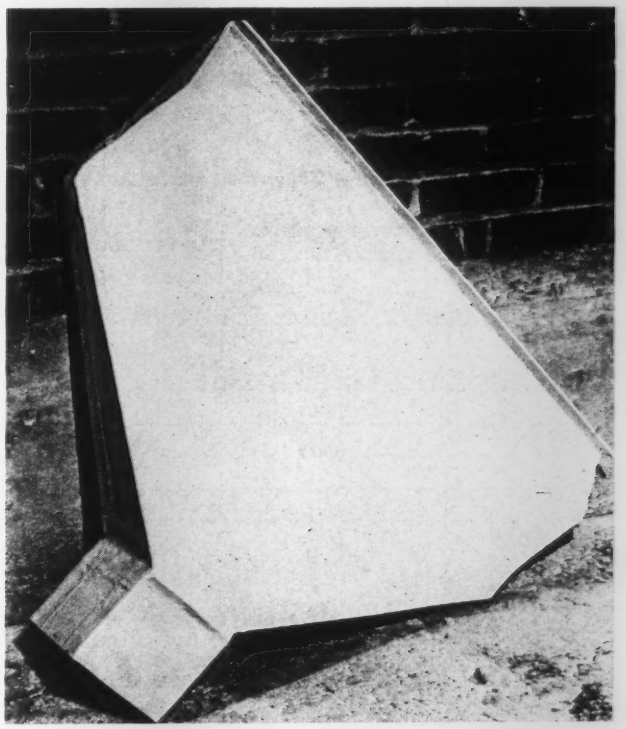
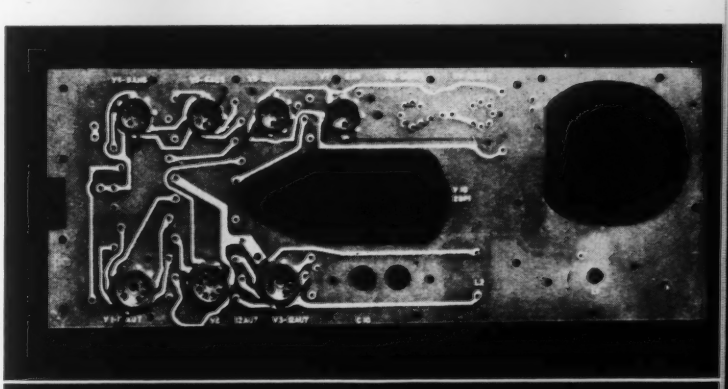


Fig. 4—Right above—Chemical bath ventilating hood made from flat epoxy laminates assembled with epoxy-saturated glass tape



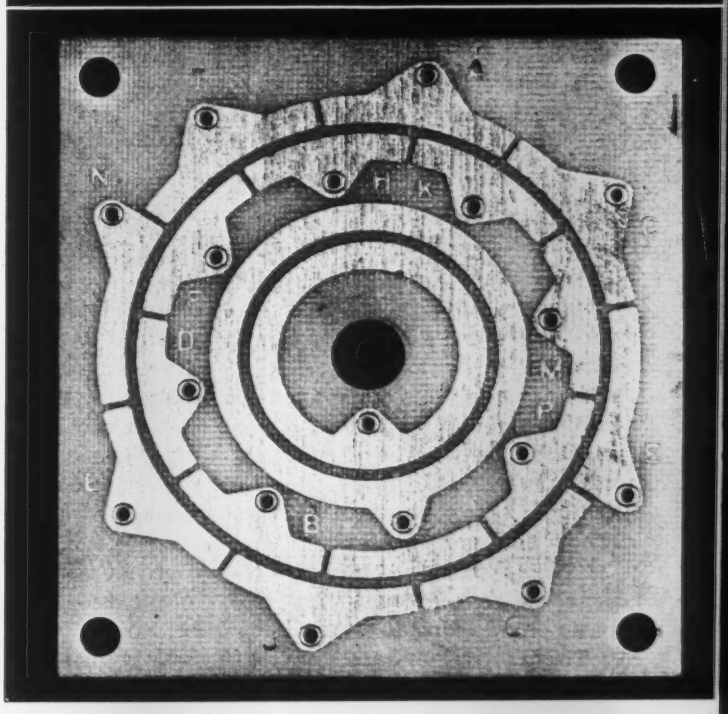


Fig. 5—Right below—Etched circuits made from Epoglas, a copper-clad epoxy and glass cloth laminate. Radar circuit, top, by Cardwell Co. also forms the base of the chassis. Copper sections in selector switch, bottom, are silver-plated by Photocircuits Inc. for better conductivity

dry resin-loaded cloth or reinforcing material. In both cases, contact pressures up to 25 psi are possible, although pressures above 25 psi result in a marked improvement in strength. For this reason, dry resins are usually used only with matched metal molds since some pressure is desirable to provide adequate flow. Pressures above 200 psi may cause some flow-out of resin, especially with very liquid

Table 2—High-Temperature Strength Retention*

Aging Time (hours at 400 F)	Ultimate Flexural Strength at 290 F† (thousand psi)	Flexural Modulus of Elasticity at 290 F† (million psi)
1	61.3	2.10
4	52.3	2.24
8	53.6	2.76
100	52.3	2.82
200	51.9	2.50
300	46.8	2.81

*Epon 828-CL and Fiberglas cloth laminate. †Held at temperature for ½-hour before testing; average of 5 samples.

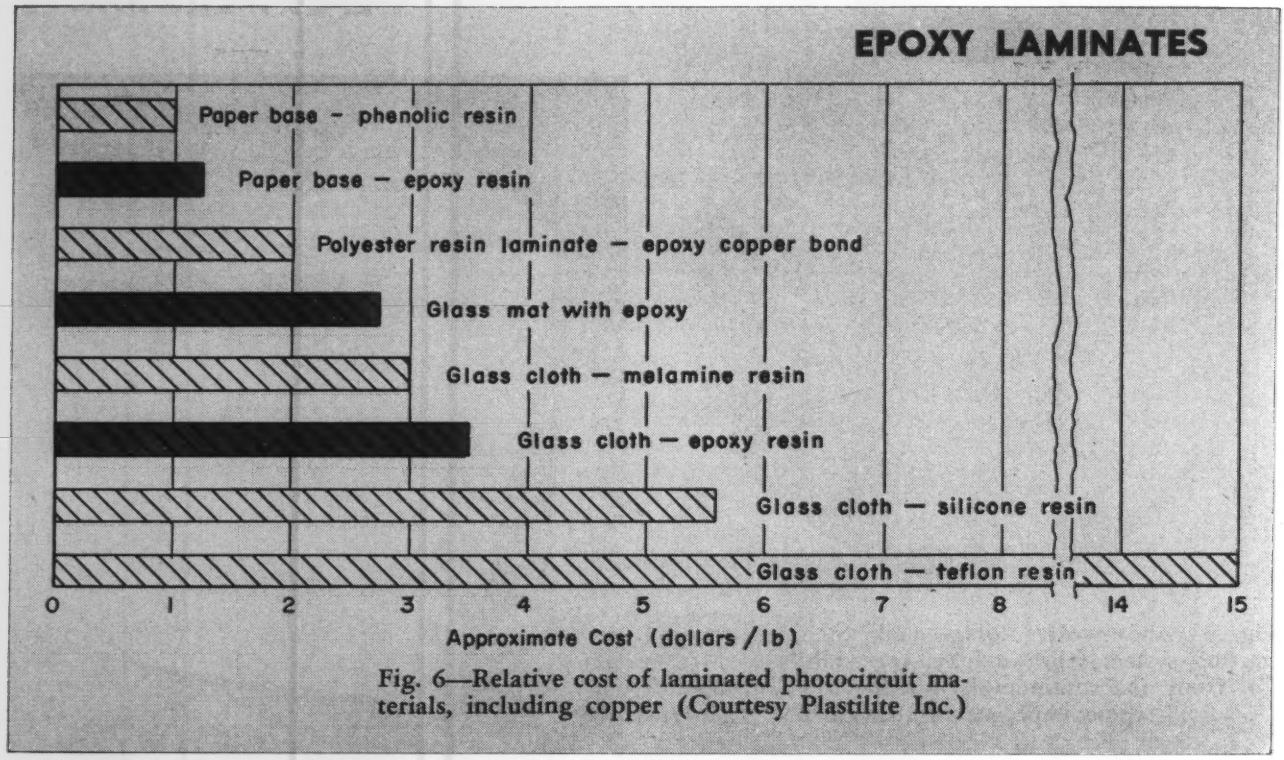


Fig. 6—Relative cost of laminated photocircuit materials, including copper (Courtesy Plastilite Inc.)

types, and a precure period at contact pressure may be necessary.

Curing is accomplished under infrared lights, in ovens, or in matched metal molds; wet layups require from 200 to 250 F, and dry moldings are generally cured at 225 to 345 F. Postcuring at 350 to 400 F for 1 hour results in maximum heat and chemical resistance.

Applications and Cost: Structural, chemical and electrical applications are all execellent possibilities. An unusual example of the structural possibilities of epoxies is the high-strength tank, *Fig.* 3, which is approximately 35 per cent lighter than comparable steel tanks. Made by running a continuous strand of glass fiber filament through an epoxy resin bath and onto a low melting point alloy mold, the tank has a burst strength of over 7000 psig. It has been tested for 10,000 cycles from zero to 3000 psig (rated operating pressure) and back to zero at 30-second intervals without failure.

Typical chemical application is the ventilating hood, *Fig.* 4, used to carry off highly alkaline plating fumes. In this application the laminating process consists of laying up flat sheets and partial curing, using weights for pressure. Sheets are then assembled with epoxy-saturated woven glass tapes, and the assembly is given a final cure.

One major electrical use for epoxy laminates has been in "printed" circuits, *Fig.* 5, in which the laminate serves as a base for a sheet of copper on one or both sides which is later etched to the desired pattern. Relative cost of various materials for this purpose is shown in *Fig.* 6, which is somewhat indicative of general costs for various laminates.

They Say . . .

"The engineer's training equips him not only with facts, but also with the capacity to deal with facts in a truthful and logical manner. As he learns to apply his disciplined, fact-discerning mind in dealing with materials, men, and money, the engineer emerges as a valuable and successful administrator. It should therefore not surprise us that a large proportion of the persons who enter the engineering profession become executives.

"Some—and the number has been increasing year by year—cease doing what might be called basic engineering to become administrators.

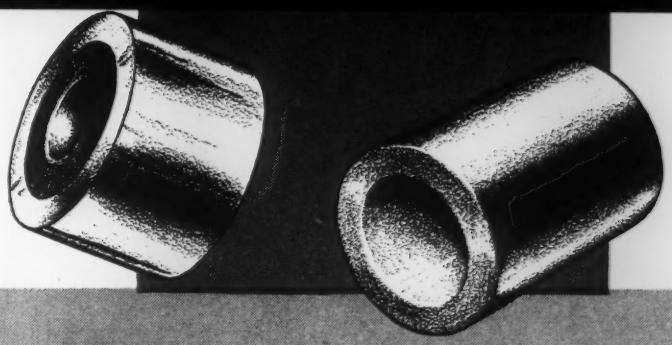
There are other reasons why the country is short of engineers. The engineering course is one of the most difficult on any college campus. Entrance requirements in engineering schools are exceptionally high.

"In 1950, about 52,000 men graduated from engineering schools in the United States. In 1951 the figure dropped to 38,000, and in 1952 to about 30,000. In 1953 it was about 23,000 and in 1954 it is expected to fall to 19,000.

"This would be a low number for peacetime production needs alone. When we consider military needs and the fact that the Russian government is educating far more men in the engineering field than we are, we can with reason speak of a terrible shortage of engineers.

"Is this still another instance of American shortsightedness with regard to preparedness?"

Abstracted from "America's Greatest Weapon" by Dr. Joseph Weil, *Ordnance*, May-June, 1954.



Design and Application of

CARBON-GRAPHITE BEARINGS

By Jack C. Schubert
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Div. of the Wickes Corp.
Saginaw, Mich.

CARBON-GRAPHITE compositions were originally developed with the electrical industry for such applications as electrodes and brushes, and are still used in large quantities for this purpose. But carbon-graphite electrical brushes were not only used to carry electric current, but also had to run dry against metal commutators for long periods of time. These early applications led to the development of a hard, wear-resistant engineering material that has many desirable bearing properties.

Being resistant to most ordinary chemicals, present-day carbon-graphite materials are ideal for bearings which depend upon the liquids being han-

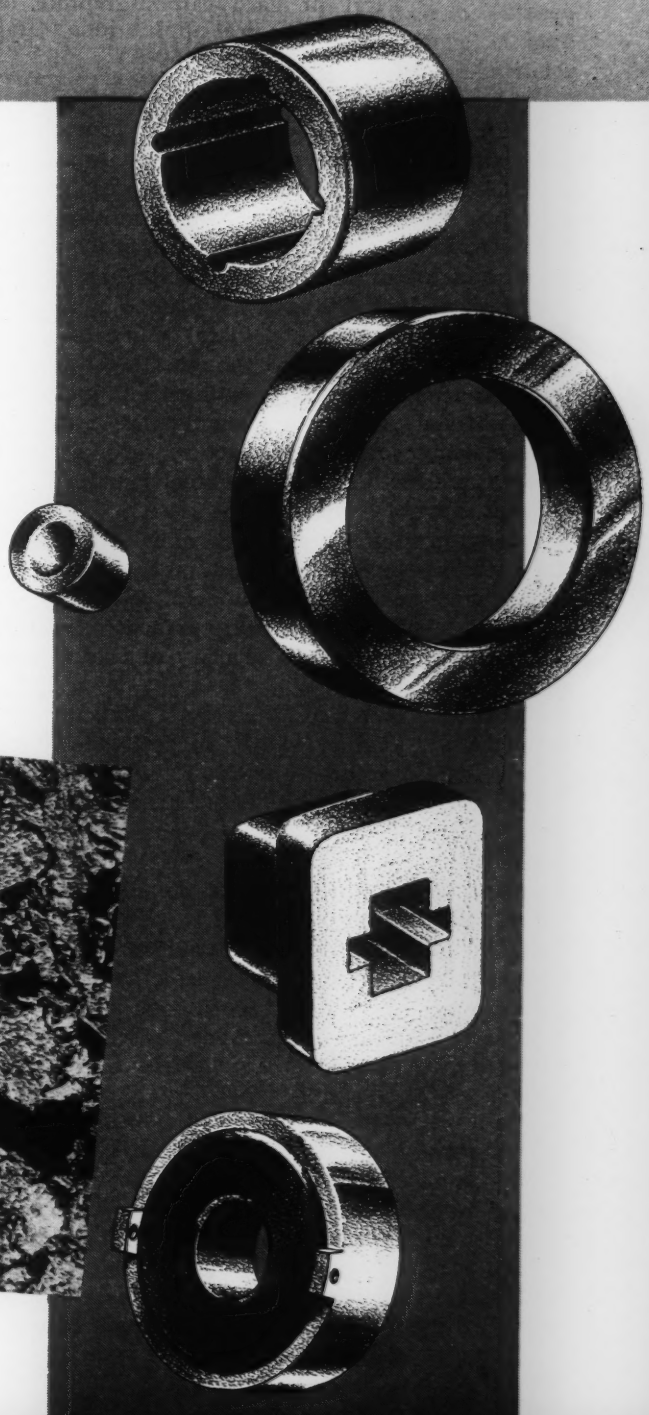
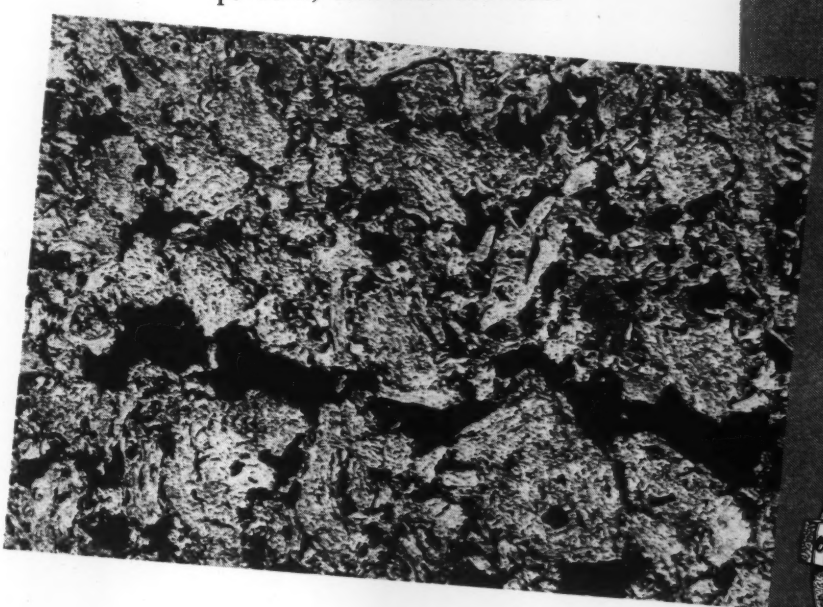


Fig. 1—Extruded carbon-graphite. Light areas are carbon and graphite particles; dark areas are voids



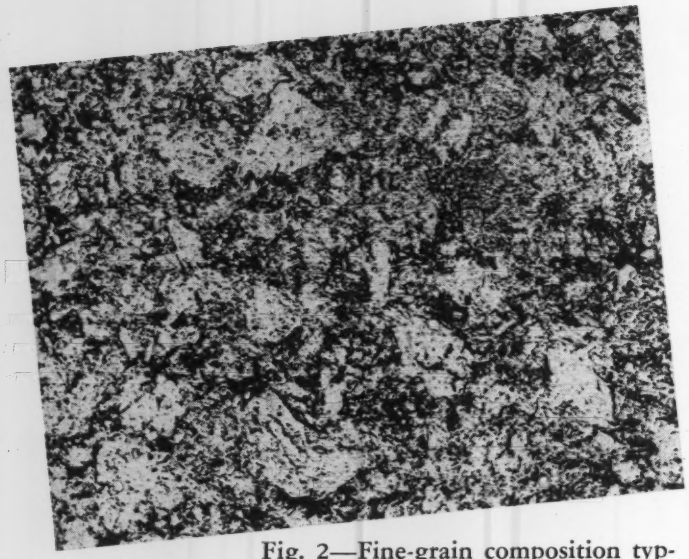


Fig. 2—Fine-grain composition typical of hard carbon-graphite used for mechanical applications (Graphitar 30-A)

dled for lubrication. All fluids will provide some lubrication to carbon-graphite regardless of viscosity. Numerous installations in gasoline, fuel oil, water, steam, and even Dowtherm have proved the material's versatility for such bearings. Best results are obtained with lubricants having a viscosity about that of water.

Scoring or welding to metal journals is completely eliminated even though the lubricating liquid is incapable of supporting the applied load; since carbon-graphite is a nonmetallic with a very high melting point, it will not score or seize even though in direct contact with steel journals at high temperatures.

Carbon-graphite resists chemical attack from all chemicals except those of a highly oxidizing nature such as fuming nitric acid. When subjected to these agents, the exposed surfaces oxidize at a rate proportional to the severity of the chemical's oxidizing power.

Another outstanding property of carbon-graphite compositions is their ability to withstand temperatures of approximately 700 F in an oxidizing atmosphere, such as air. If bearings are protected by a neutral or reducing atmosphere, even higher temperatures will have no harmful effects. High-temperature bearing applications are thus a natural, since ordinary lubrication is usually difficult to apply and of doubtful value. With carbon-graphite bearings, properly used, unusually long life can be expected. A continuous supply of dry graphite lubricant is present in the material's structure to give long trouble-free service.

Development of Present-Day Compositions: Early carbon-graphite compositions were rather crude. Coal, coke, carbon and graphite of various sizes and shapes were mixed with a pitch binder, then slugged or extruded to block or rod form. These green forms were then furnaced to reduce the binder to carbon and knit the particles together. The end-product was entirely satisfactory until service requirements and new applications demanded better carbon-graphite compositions. To improve the material the entire manufacturing process was controlled more closely. Particle size of the raw materials was reduced from lumps to accurate mesh size, better blending and mixing techniques were devised, and the extrusion process and furnacing were improved.

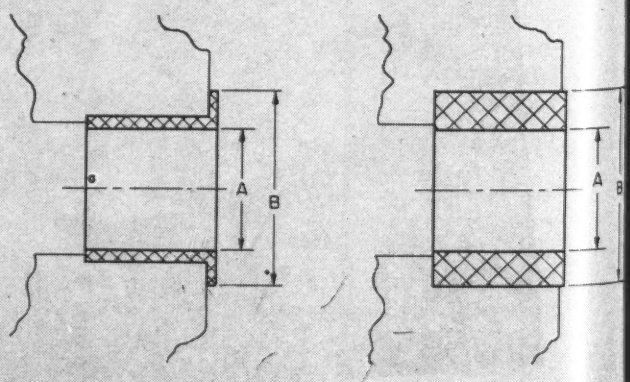
Although resulting stock, *Fig.* 1, gave better properties for mechanical applications such as seals and bearings, distribution of particles and voids was uncontrollable. To produce a fine grain stock suitable for such mechanical uses, the powder had to be ground finer and held to a specific mesh size. Binder must be evenly distributed around each particle. Much research was devoted to this phase of manufacture. Since the powders used can almost be compared in particle size with smoke, some of the problems encountered in controlling this smoke-like mixture to spread a minimum amount of binder around each particle can easily be realized. Excessive binder in the mix causes high shrinkage and varies the physical properties after furnacing. Additionally, high-pressure molding processes are necessary to control porosity.

With these manufacturing improvements, a material similar to that shown in *Fig.* 2 can be reproduced again and again with identical structure and physical properties, but strict quality control on all phases of manufacturing is required. Even furnacing time is closely regulated since too fast a cycle will not allow volatiles to escape freely and ruptures the partially furnaced piece.

With this type of carbon-graphite, a wide selection of grades is available, from all-graphite stocks to an all-carbon stocks, with varying hardness, strength, and performance properties.

Rigid quality control on each manufacturing operation is a must. This may seem to be an unimportant point, but the fact remains that several different grades can have the same physical

Fig. 3—Thin-wall flange bearings, *a*, are more fragile and harder to produce than more rugged types, *b*. Same thrust load capacity is given by either design



properties, yet give entirely different results on a given application. Changes in manufacturing techniques, such as mixing, pressing and furnacing, will change the material from the performance standpoint.

Properties of Carbon-Graphite: A bearing material is expected to have certain properties. Some of the important properties used to evaluate a material as a bearing are:

1. Low friction
2. Score resistance
3. Compressive strength
4. Fatigue strength
5. Wear resistance
6. Thermal conductivity
7. Composition and structure
8. Modulus of elasticity
9. Corrosion resistance
10. High melting point

Bearing materials operating nonlubricated or under extremely thin-film lubrication require many desirable properties to give satisfactory performance. With carbon-graphite there is no tendency toward surface damage since carbon-graphite operating in contact against a steel shaft will not weld or attach itself to a metal shaft. Experience has proved that a bearing material displaying high hardness and low shear strength will operate with low friction.

Although carbon-graphite will not weld, minute layers are sheared off the bearing surface during the run-in period. This initial self-lapping causes a relatively high wear rate during the first few hours of operation. However, the bearing surface quickly takes on a high polish and further wear is virtually eliminated. Wear experienced during this wear-in period is very little, being in the neighborhood of 0.0001 to 0.0002-inch. After this, the bearing surfaces are suitably mated together. The shaft will then have a thin graphitic film that may be thick enough to give the area a chocolate-brown color, or be of such minute thickness that no discoloration is visible. This condition is desirable, since once these polished surfaces are attained, the bearing will operate with the lowest wear rate.

The exceptional high hardness and strength obtained in bearing grades of carbon-graphite contribute to its low friction and wear resistance. Several standard grades average 100 in Shore Scleroscope hardness. Because of high hardness, these grades are also brittle and not recommended for high shock loads. Fatigue strength at normal and high operating temperatures is sufficiently high to prevent cracks or chipping during the required life for most bearing applications.

Conformability of carbon-graphite is good because of its low modulus of elasticity. This value ranges between 1.5 and 3.0 $\times$ 10^6 depending on the grade. It will and can be deformed within limitations to adjust for shaft misalignment, shaft deflection, or other geometrical errors.

Its ability to embed large amounts of abrasive particles or dirt is limited. Use of clean, filtered liquids is desirable; in fact, mandatory if long service life is expected. Dirt and abrasive particles that roughen the shaft bearing surface will cause rapid wear on carbon-graphite.

Although the finished surface of a carbon bearing does not lend itself to inspection by conventional surface-roughness inspection equipment, surface finish is very important. A smooth grind is the accepted standard finish specification for bearing surfaces. When necessary, lapped inside diameters with a high polish are obtainable, as are highly lapped flat surfaces. Surface-roughness readings of a very low magnitude can be obtained but, due to the inherently porous structure, consistent readings are impossible. Sharp probes scratch the surface and destroy the mirror-like polish; another reading over the same area will then give an erroneous reading. The accepted method of inspection is by visual comparison with production samples from a lot that has proved satisfactory in operation.

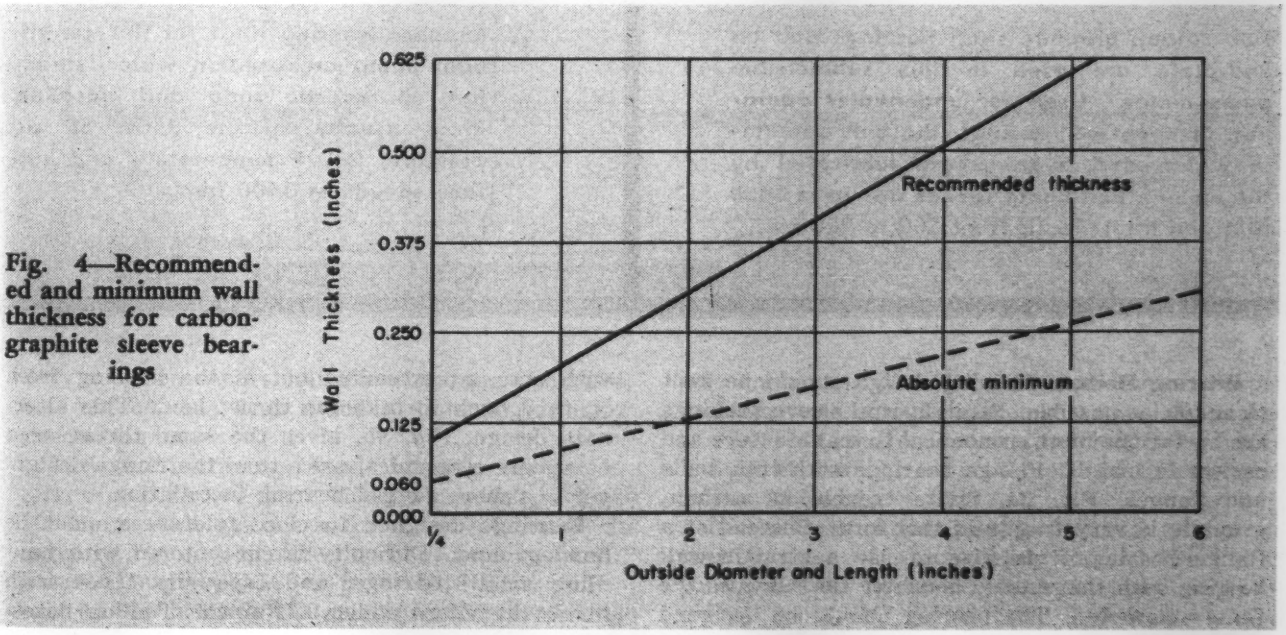
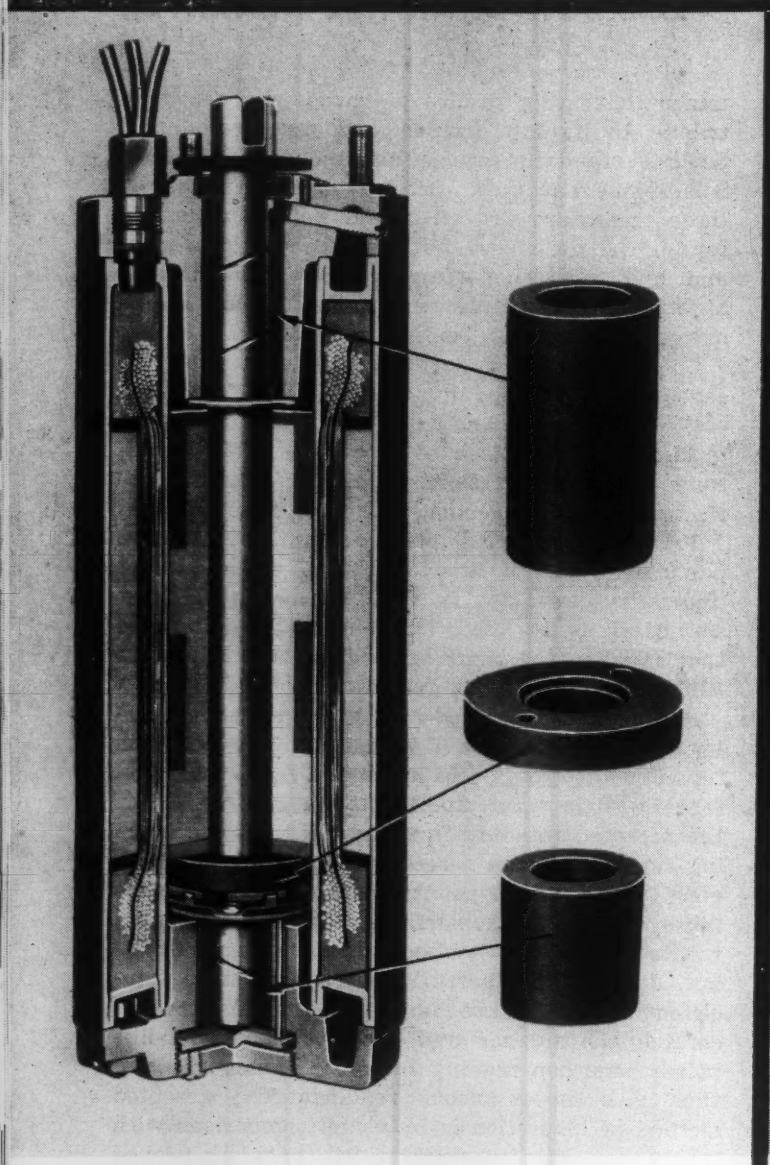
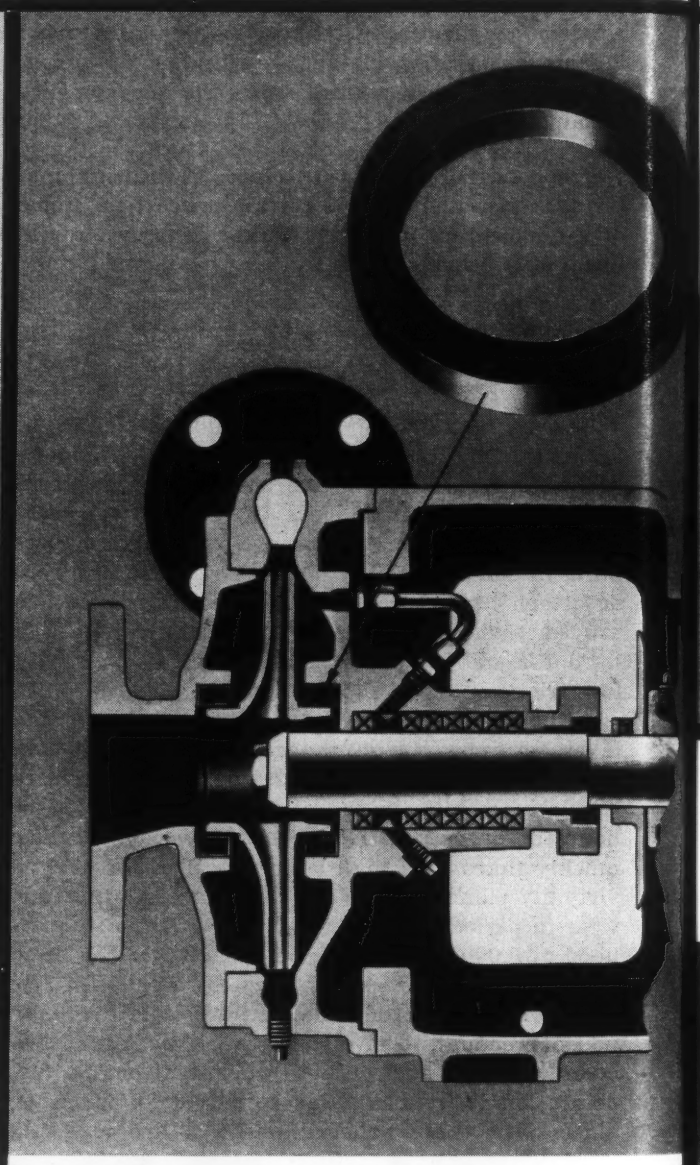


Fig. 4—Recommended and minimum wall thickness for carbon-graphite sleeve bearings



Shaft Bearings; Thrust Bearings

Two carbon-graphite shaft bearings and an end-plate are used in this submersible pump-motor. Used for underwater operation in deep-well casings, the unit operates in water, and bearings are lubricated by the water. Rotational speeds are up to 3450 rpm and thrust loads from 300 to 900 psi.



Wearing Rings

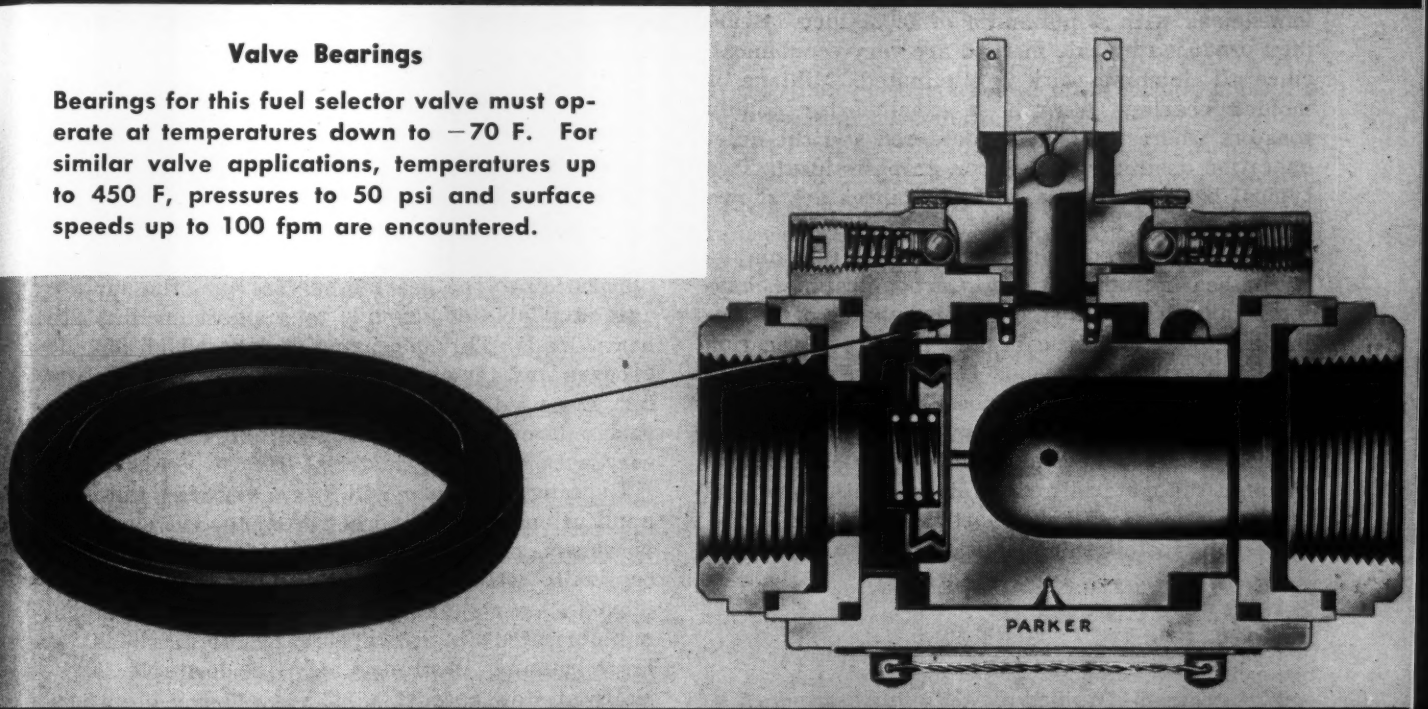
Impeller wearing rings for this centrifugal pump are used in water, steam, hot oil, caustic soda and gasoline. Rings usually operate under 50 psi pressure, 200 F temperature and surface speeds of 3400 fpm.

Bearing Design: Bearing design should be kept as simple as possible. Straight-wall sleeve bushings are by far the most economical to manufacture and easiest to install. Flange bearings with thin walls and flanges, *Fig.* 3*a*, invite trouble as carbon-graphite is very fragile in this form. Instead of a flange bearing, it is wise to use a straight-wall bearing with the outside diameter the same as the flange diameter. The bearing should be designed with one end extending out of the housing from $\frac{1}{16}$ to $\frac{1}{32}$-inch to take the thrust load. This alternate design, *Fig.* 3*b*, gives the same thrust area at a more economical price than the flange design, yet is a more rugged bearing installation.

Bearings designed to close tolerances must be finish-ground. Difficulty is encountered with handling small bearings, and especially those with inside diameters under 0.125-inch. Tooling neces-

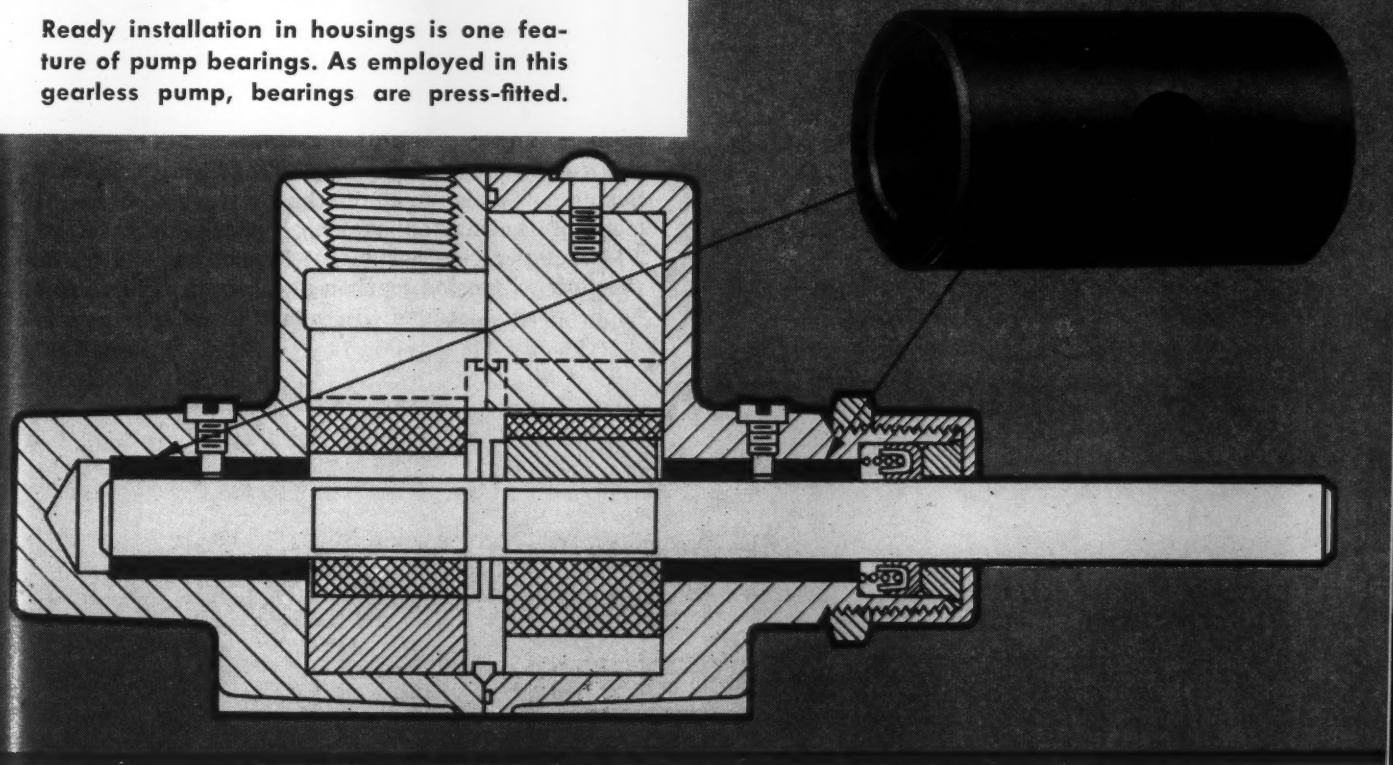
Valve Bearings

Bearings for this fuel selector valve must operate at temperatures down to −70 F. For similar valve applications, temperatures up to 450 F, pressures to 50 psi and surface speeds up to 100 fpm are encountered.



Pump Shaft Bearings

Ready installation in housings is one feature of pump bearings. As employed in this gearless pump, bearings are press-fitted.



sary to grind such small diameters must be rigid, and no tool has been found to hold up for large production runs.

Thin wall sections on larger bearings are not desirable and should be avoided whenever possible. Minimum wall thickness for given diameters is given in *Fig.* 4. Use of recommended thickness will assure a bushing that can be handled and installed easily. Six inches is the maximum length for one-piece bearings up to 6 inches in diameter. Larger bearings with outside diameters up to 13¾ inches can be built up to any required length by using individual bearing segments of approximately 2 inches in length.

If the application permits liberal tolerances, then the use of a completely molded bearing is possible. The tolerances necessary are approximately 2 per cent on diameter dimensions with a

minimum of 0.010-inch and 10 per cent on length dimensions with a minimum of 0.030-inch. Bearings produced by this method are very economical, since all finishing work is eliminated. Millions of molded bearings have been supplied for pop-up toasters where the heat encountered and the quiet operation desired make carbon-graphite ideal. Two typical bearing designs with tolerances are shown in *Figs.* 5 and 6.

Lubrication grooves are unnecessary in a majority of bearing applications. Carbon-graphite, having a minute porous structure is capable of retaining a supply of lubricant and feeding lubrication to the bearing surface as required. For applications in which maximum possible bearing surface is necessary to support heavy loads, impermeable grades are recommended since fluids cannot flow through the material; therefore, a continuous solid surface is provided to support the lubricating film. On such installations lubricating grooves may prove beneficial, and grooving designs conventional with metal bearings are satisfactory. Also, when liquids which may contain abrasives are being handled, grooves are helpful in freeing the bearing surface of large particles.

For thrust bearings, a grade that is slightly porous will supply the lubricant to the thrust bearing surfaces. The problem of getting the lubricant between the flat mating surfaces is automatically solved since the controlled porous structure meters lubrication to the bearing surface; yet the surface area available is enough to support medium to heavy loads. Thrust bearing designs which include grooves and tapered lands to create a lubricating film are used on specialized applications. Such a design is expensive to produce and seldom necessary with a bearing material like carbon-graphite.

Running clearance will vary with the different applications. The general recommended clearance is shown on *Fig.* 7. With lubricated bearings, especially where low-viscosity lubricants are employed, closer running clearances can be used. On nonlubricated high-temperature applications, a large running clearance may be desirable, especially at slow speeds.

As a high-temperature bearing material, carbon-graphite retains its mechanical strength at elevated temperatures and will withstand high pressures without extruding or breaking up. Carbon-graphite should be held secure in a metal retainer or housing at the highest operating temperatures. This assures good support to the outside of the carbon-graphite and prevents the possible loss of the bearing due to the housing expanding away from the bushing. Carbon-graphite has a very low coefficient of thermal expansion, approximately 1.5 × 10^{-6} inch per inch per degree F. To compensate for this low expansion, carbon-graphite bearings must be properly installed. In many cases the method

Fig. 5—Molded toaster guide bearing showing typical tolerances

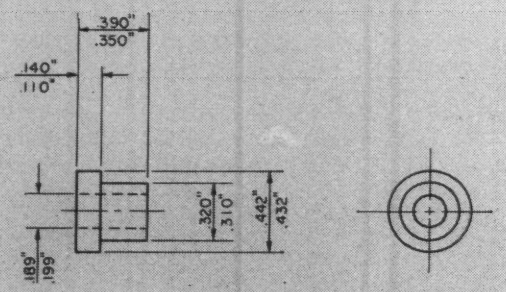
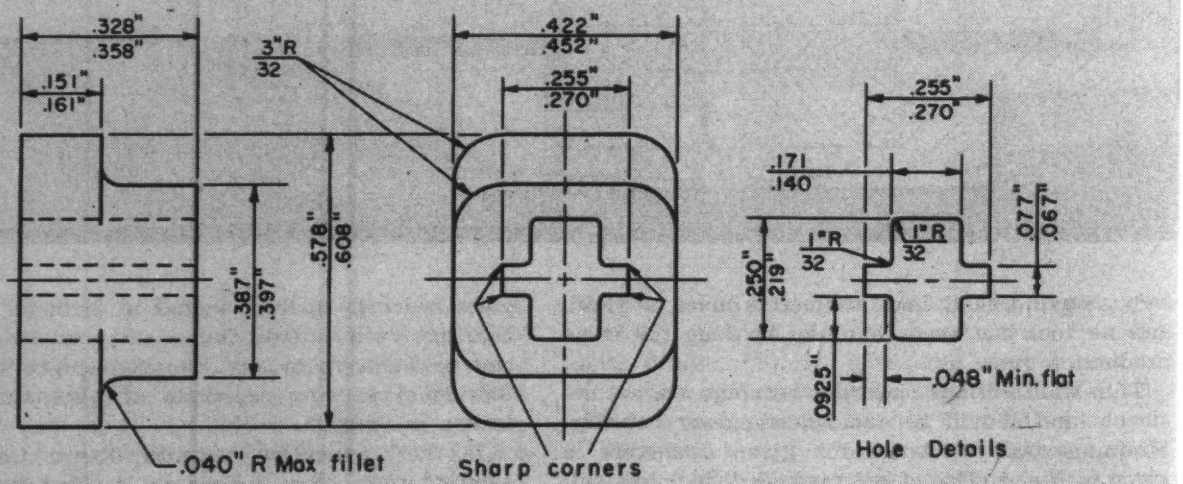


Fig. 6—Slide bearing for toaster



may differ greatly from that used to install metal bearings. Whether the carbon-graphite bearing is installed directly into the housing or into a metal shell which in turn is inserted in the housing, the same factors must be considered.

Housings and Shafts: Large interference fits between the carbon-graphite bearing and the metal housing are usually necessary for high-temperature operation. This can be accomplished by either press or shrink fit. The size and the interference necessary will determine which method is most suitable. Pressing in a bearing with more than 0.005-inch interference is not recommended, since the outside diameter will begin to shave off. If larger interferences are necessary, shrink fitting is the easiest method of installation. Proper installation of carbon-graphite bearings automatically compensates for the material's low coefficient of expansion. With a carbon-graphite wall-thickness to metal wall-thickness ratio never greater than one, reduction in inside diameter accounts for approximately 85 per cent of the interference fit.

Metal-backed bearings are more rugged and will withstand much more abusive handling than unprotected bearings. This type of bearing is manufactured to specifications for particular applications, and any type metal for the backing can be used.

Selection of a proper mating bearing material is important. Hard mating materials generally give the lowest friction and longest service life. Certain applications require specific properties, and in many installations shaft hardness has to be sacrificed to obtain corrosion resistance. For use in corrosive media, the mating material must be highly corrosion-resistant, since a rough corroded shaft will cause wear. Stainless steels such as the 18-8 type are excellent and will usually provide a smooth, clean mating surface. Although softer materials are not as desirable, they are entirely satisfactory for most applications; many are compatible with carbon-graphite and can be used on chemical applications. Other materials such as cast iron, Nitralloy, hardened steel, and hard chrome plate are also recommended mating materials.

A *PV* value of 15,000 is used as a critical point to evaluate loads and speeds for nonlubricated bearings, while a *PV* value of 150,000 is used for lubricated applications. This value is the product of the unit loading of the projected area in psi and the peripheral speed of the shaft in fpm. A length of 1½ times the diameter is generally optimum, but this rule is not rigid and the application and installation will determine the necessary length.

Amazingly low coefficients of friction have been recorded on tests using water as the lubricant. Tapered-land thrust bearings with an outside diameter of 2¾ inches operating at speeds up to 3450 rpm and loads of 110 psi operate with coefficients of friction as low as 0.002. This kind of performance can be expected when operating conditions permit hydrodynamic lubrication to support the load. With lubricants such as water, having very low film strength, little friction is created if the loading is such that it does not collapse the film.

Friction for dry, nonlubricated operation is somewhat higher. The exact value depends on many contributing factors such as load, speed, journal material and finish, running clearance, alignment, etc. Generally speaking, nonlubricated applications should be of low-speed or lightly loaded types; however, some installations have given amazing results operating under very severe conditions. Carbon-graphite compositions are hygroscopic; they will absorb moisture from the air to serve as lubrication and cut down friction.

On a water-submersed motor application, two radial bearings and a thrust bearing plate of carbon-graphite were required to last for a minimum of 10,000 hours. Actual field experience shows little, if any, wear and the motor operates with lower friction than a similar unit with antifriction, oil-lubricated bearings.

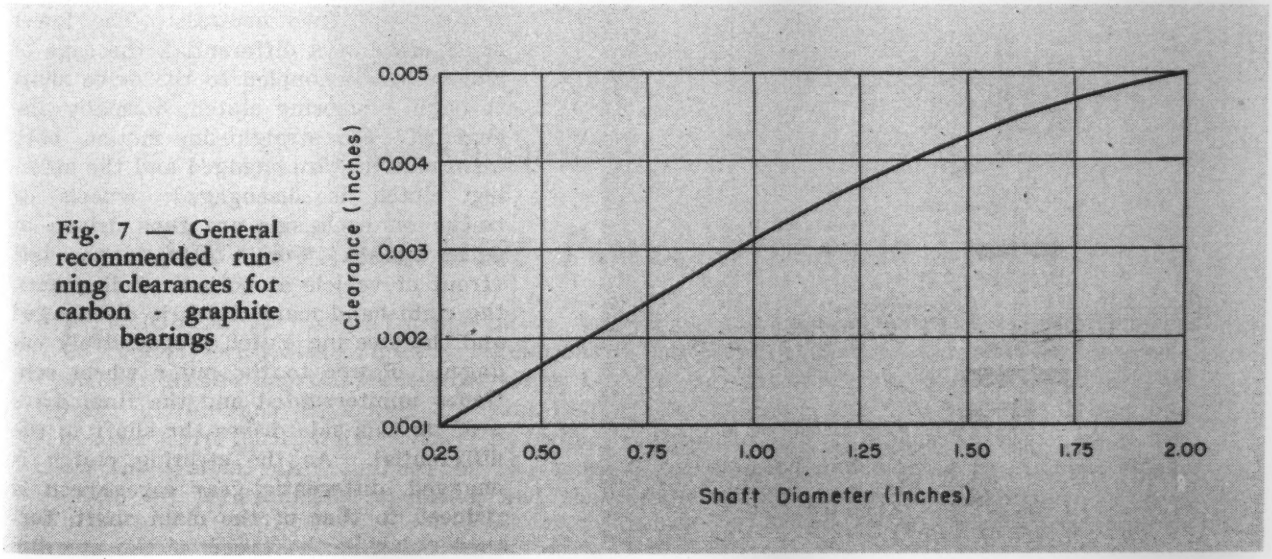
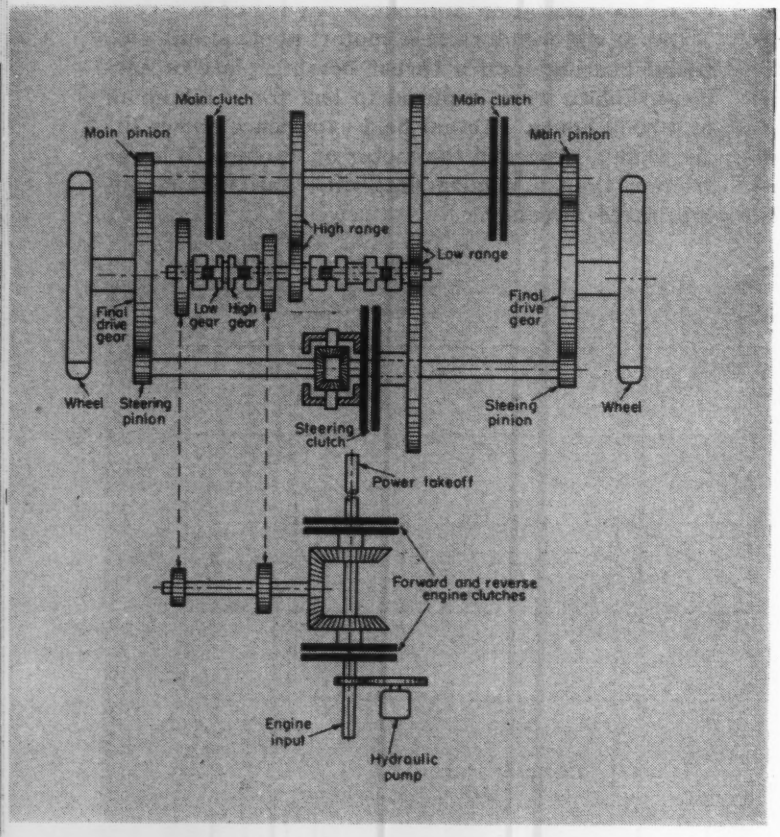


Fig. 7 — General recommended running clearances for carbon - graphite bearings

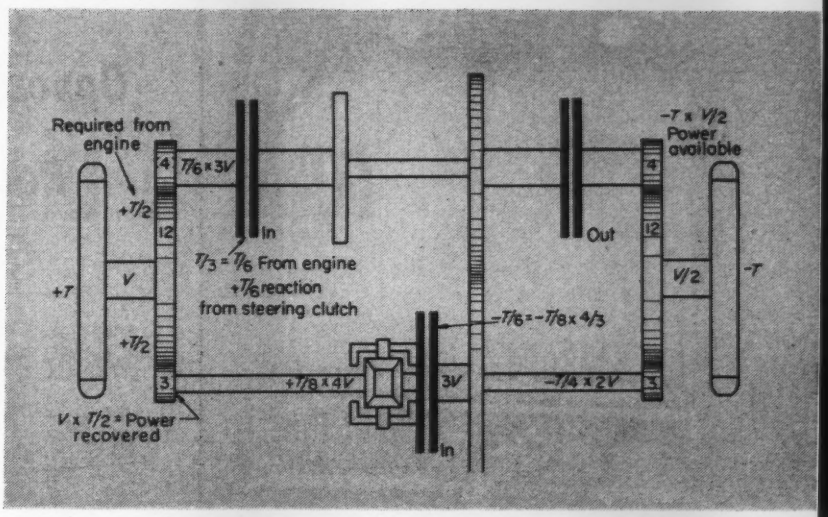
Regenerative Transmission Steers Tractor

A NEW type of regenerative transmission for four-wheel tractors manufactured by Gates & Hardy Ltd., London, permits power to be applied to all four wheels, and steering to be accomplished by changing relative velocities and torques of the wheels on opposite sides of the vehicle. Although turns are similar to those of a crawler tractor, except that the inner wheels (or tread sprockets if adapted) are not braked. In conventional steering, with a differential, extra power must be supplied by the engine for the same mean vehicle speed because of the increased overall gear ratio when inner wheels are slowed down. With the Regenomatic transmission, the "braking" power for the inner wheels is transformed into driving power on the outer wheels to help turn the vehicle.



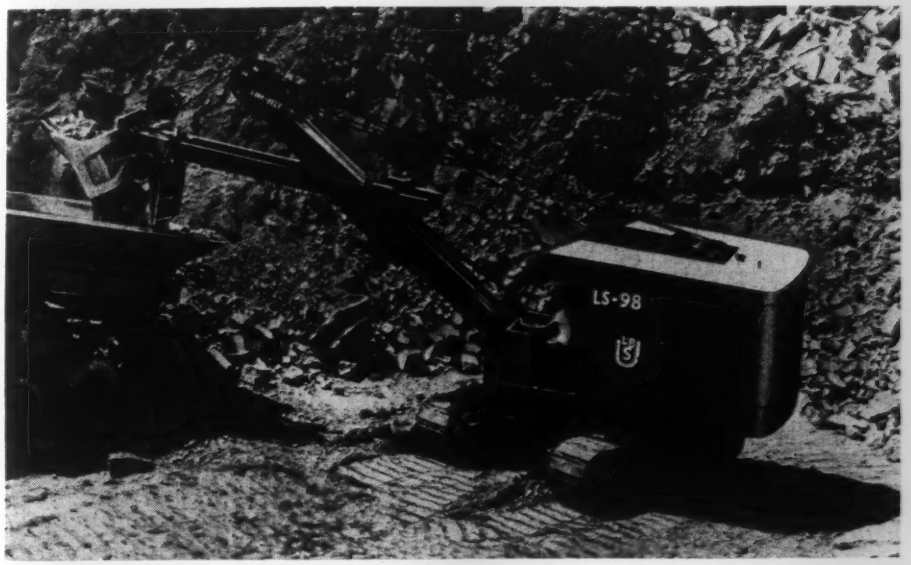
Transmission Proper consists of two shafts; the main shaft being broken by two clutches which are normally engaged by spring or, in the case of large transmissions, by oil pressure. This shaft is driven from the engine shaft through the gear-changing mechanism which gives four speeds forward and four reverse with two neutrals. The lower shaft contains a differential, the cage of which can be coupled to the drive shaft through a steering clutch, normally disengaged. For straight-line motion, both main clutches are engaged and the steering clutch is disengaged; wheels or tracks on each side are thus driven at equal speeds. For a turn to the left (front of vehicle at bottom of diagram), the right-hand main clutch is disengaged and the steering clutch progressively engaged. Power to the outer wheel continues uninterrupted and the final drive gear on this side drives the shaft to the differential. As the steering clutch is engaged, differential-gear cage speed is reduced to that of the main shaft, further reducing the speed of the steering

pinion on the inside wheel. Thus, the inner wheels or tracks slow down and the machine turns in the desired direction.



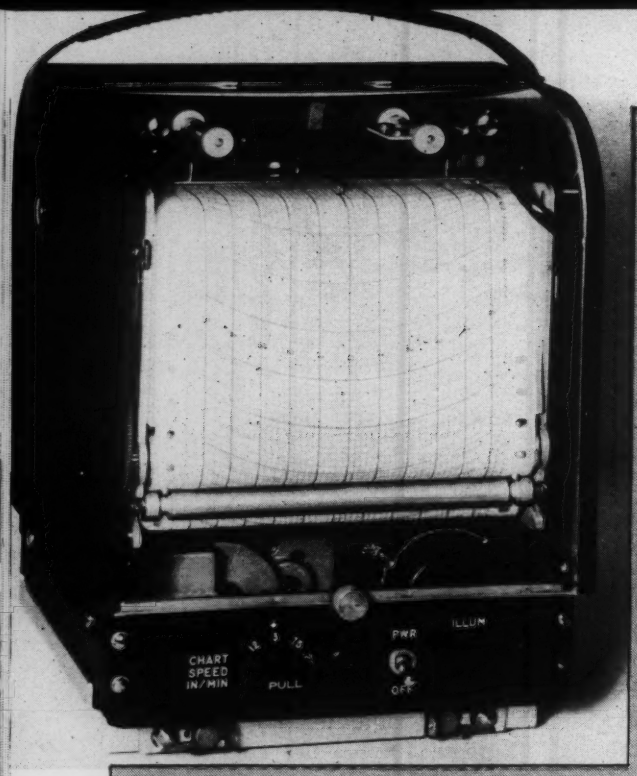
Negative braking effort on the slowed-down side of the vehicle is completely transferred to active propulsive effort on the faster moving side. In turns of less than 2 radians (90 per cent of all steering) the engine is not called upon to supply any extra power for turning. For a theoretical turn of the inner wheels of one track width, the inner wheels must be braked and thus produce a torque of $-T$ at a velocity of $V/2$. This braking effort must pass to the inside bevel gear of the differential; the steering clutch coupled to the main clutch line imposes a reaction on this drive which is balanced by the torque it introduces into the differential cage. Because of the reversal effect of the differential, the minus (braking) torque is transformed to a plus (driving) torque, and reaches the driving side as a torque of $T/2$ at a velocity of V. Demand on the engine is thus reduced from TV in the case of a braked turn to $TV/2$.

Several other advantages are evident. Since steering pinions are always smaller than the main pinions, an extra low gear is available by disengaging both main clutches and engaging the steering clutch. If all three clutches are engaged, the entire mechanism is locked and becomes, in effect, a parking brake. If the cage of the differential is fitted with a brake, and this is actuated instead of the steering clutch, a true spin turn results, in which one set of tracks or wheels is driven forward and the other set runs backward at equal speeds.

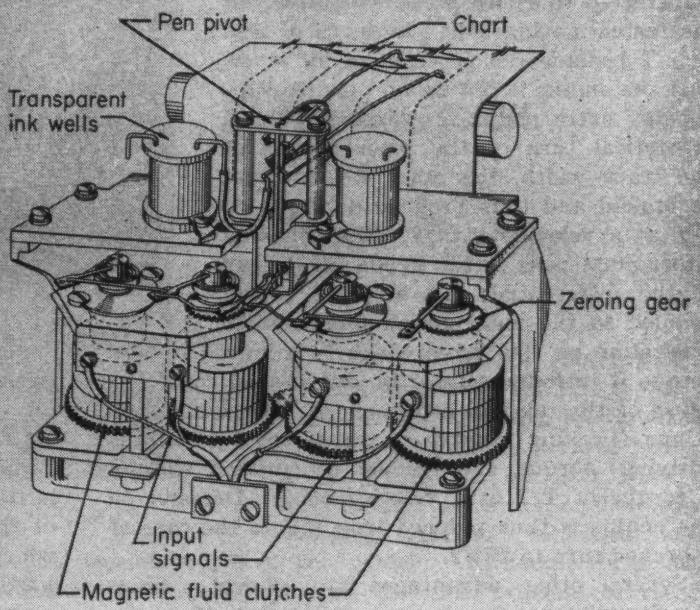


Shovel-Crane Uses Power Hydraulic Controls

DESIGNED for easy transportation to comply with state highway regulations without dismantling and reassembly, a new 1-yard shovel-crane developed by Link-Belt Speeder Corp. incorporates a power hydraulic control system. All clutches of the new LS-98 are hydraulically operated, and the new clutches are said to be self-adjusting for temperature changes and normal lining wear. Power load-lowering reversing clutches are available for either or both front and rear drums. Digging brakes, as well as all traveling, steering and digging functions, are controlled from the operator's position.

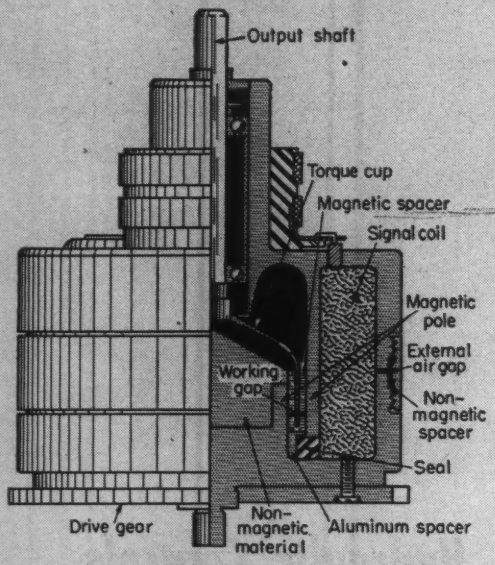


Opposed Fluid Clutches Drive Recording Milliammeter

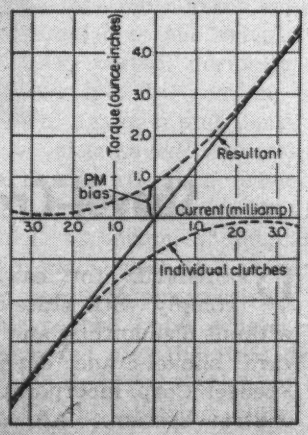


OPPOSED magnetic particle clutches drive the recording pens in an ink-writing recording milliammeter developed by Texas Instruments Inc. Using standard curvilinear chart paper, the recorder features two independent channels and four drive speeds.

Two magnetic fluid clutches, with outer clutch bodies geared together, rotate in opposite directions. Deflection of the linked output mechanism is the resultant of developed torque of both clutches. Clutch signal coils are connected in series with polarity reversed.

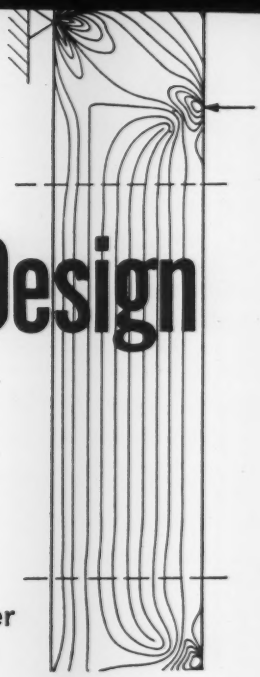


Clutch body is rotated by means of a base-mounted spur gear. Input signal is applied by carbon brushes to solid silver slip rings at the top. Changes in magnetic flux from the signal coil through the working gap change the viscosity of the magnetic fluid (essentially an iron powder mixed with oil), thus altering the drag on the torque cup and its output shaft. A bias is applied to the clutch with Alnico permanent clutch magnets to produce a linear change in output torque and to keep the iron particles in suspension.



Movement responds linearly to input signals from 10 to 500 microamperes with a nominally developed torque of 0.125-ounce-inches per 100 microamperes. Deflection sensitivity is 6 degrees per 100 microamps, but may be changed by a different load spring rate. Clutches are biased with two permanent magnets each, adjustably mounted on the movement frame.

CONTEMPORARY DESIGN



Stress Analysis in Design

Part 4—How to Approach the Problem

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Lehigh University
Bethlehem, Pa.

ONE IMPORTANT problem attending the development of an original design is the selection of an economical procedure whereby a given member can be developed so that it will have sufficient strength at every point but will be no stronger at any point than is considered necessary or desirable. The procedure selected will usually involve paper and pencil methods of stress analysis to secure some initial development. Further development, if needed, may be obtained by procedures involving paper and pencil and/or experimental stress analysis, or possibly no stress analysis at all. This article is devoted to a description of common procedures used to develop a machine part for proper strength together with some factors which influence the choice of an economical procedure. Because the methods of stress analysis are usually an important part of a development program, factors which influence the choice of a method of stress analysis will be an inherent part of the discussion.

Initial Development

One outstanding value of paper and pencil stress analysis methods is that they afford the only means of investigating mechanical strength prior to fabrication of the first part or model and therefore afford the only reasonable means whereby strength may be investigated in the initial stages of an original design. Experimental development procedures are useless *per se* at this time because there exists nothing upon which to experiment. If the new design were merely a modification of some part of an existing machine, experimental methods could possibly be used immediately, but to attempt fabrication and testing of a new machine without at least a rough paper and pencil development is a most impractical approach. When the proportions of new machine members are first being developed, a detailed investigation of strength should be avoided. Obviously critical sections of each member should be analyzed only to the extent that no design will be grossly misrepresented. There are several reasons for this procedure:

1. *Design requirements other than strength* need often be based on only approximate sizes. Shape, size, material and processing which describe a machine member must be suited to the functional, environmental (space, loading, etc.) and fabricational requirements. Each of the latter factors may influence one or more of the former specifications so that due to this often complex interdependence, not all requirements are likely to be satisfied in the initial attempts. Until other design requirements have been satisfied, a detailed stress analysis should be avoided since it may be wasted if changes are made.

2. *A rough but comprehensive picture* of an assembly or an entire machine often can be developed from approximate sizes. Such information may provide a basis upon which to decide the future disposition of the project. In general, it is good policy to maintain all load-carrying members at the same level of development whenever possible because of the structural influence of one component upon another. Premature refinement of only certain components leaving other equally im-

portant members in a rudimentary stage may render the detailed analysis useless if changes must be made.

3. *More than one design* for a given application might desirably be investigated so that the one which represents the best combination of features may be chosen. If an unnecessarily complex stress analysis is made for each design, then the analysis of those eventually rejected would represent wasted time, money and effort.

The elementary formulas of strength of materials and possibly certain empirical relations are of value in developing initial designs. For simple shapes, these formulas can often be solved explicitly for an important dimension (such as diameter) but in any event they are simple to apply and are adequate for the analysis of many shapes and load combinations. They are often used in cases more complex than those for which they were developed and while admittedly in error, the results may have value at least in indicating proper orders of magnitude. The designer should use his knowledge of and experience with past designs to modify the results obtained from an inexact analysis. Data compiled from past design procedures and from experimental analysis of similar existing machines or components may facilitate making more reasonable assumptions and decisions in the early stages of design, thereby reducing the extent and number of revisions required in more advanced phases of development.

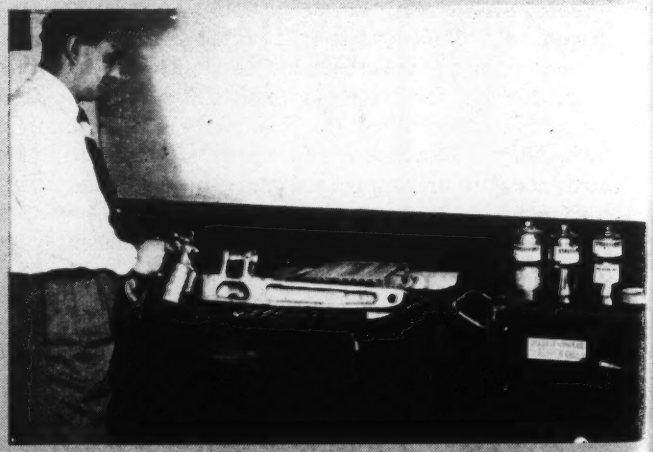
Refinement

The ideal machine member is one which has sufficient strength at every point but is no stronger at any point than necessary to withstand the applied load. The ideal is usually approached by a process of refinement in the design. Although simpler members may receive sufficient refinement from the elementary analysis used in the initial development phase of design, more complex parts will require further attention. Refinement may be obtained by using experimental testing techniques, which may or may not involve theoretical or experimental stress analysis, or refinement can be obtained by use of extended paper and pencil methods alone. If further refinement is to be obtained by the methods of theoretical and/or experimental stress analysis, then the greater the refinement desired, the more nearly the methods of stress analy-

Stress Analysis in Action

. . . how load capacity of a steel casting was more than doubled—with 5 per cent less weight

This case study, supplied by Robert J. Franck, Superior Steel and Malleable Castings Co., Benton Harbor, Mich., exemplifies a rational approach to design refinement via experimental stress analysis. As originally designed, the component—a 60-pound truck-spring lockout beam—failed in service due to tensile stresses despite apparently enough material in the critical regions.



First stage of the redesign was an experimental investigation of the actual stresses. Here brittle lacquer (Stresscoat) is being sprayed on the beam preparatory to simulated loading

sis must indicate the true strength of the member. This means possible attention to complex states of stress, residual stress, stress concentration, dynamic effects, inelastic effects and all such influences which determine the true stress within a member. It also requires choosing the proper mode and theory of failure which together with consideration of the effects of environment and time, determine the maximum stress the material can withstand. Finally, in order to refine a member, attention must be focused on several portions of the member to insure that the requisite amount of material is provided. Before deciding which procedure to use in refining a part, it should first be decided whether or not refinement is necessary and if so the extent to which it must be carried.

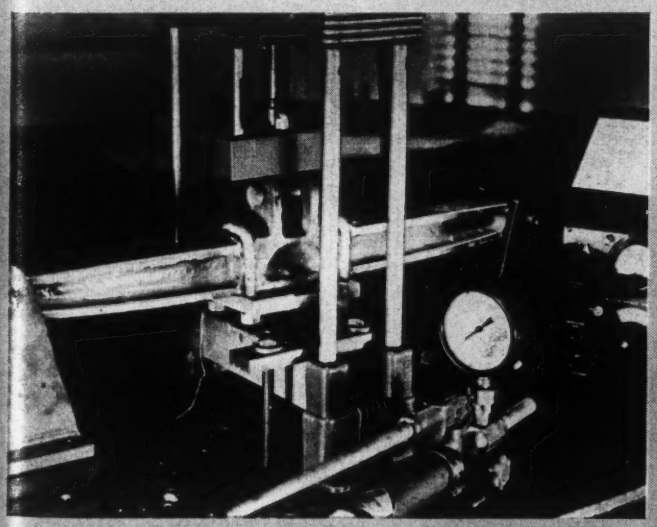
One reason why refinement of a machine part may be required is to obtain a greater degree of certainty regarding the safety of the design. There are persuasive reasons why failure of machine parts in the field cannot be tolerated. Most serious of these are human injuries and property damage, and attendant liability, resulting from an unsafe product. Much money is lost each year in settling lawsuits and claims brought about by such failures. Another serious consideration is that failures will impair the manufacturer's reputation. Designs involving considerable risk require that the designer be certain that his design is safe. The following considerations may aid the designer in judging what confidence he may place in the strength of his design and whether or not further refinement is necessary to insure sufficient strength:

1. *Comparison* with similar satisfactory designs of the past.

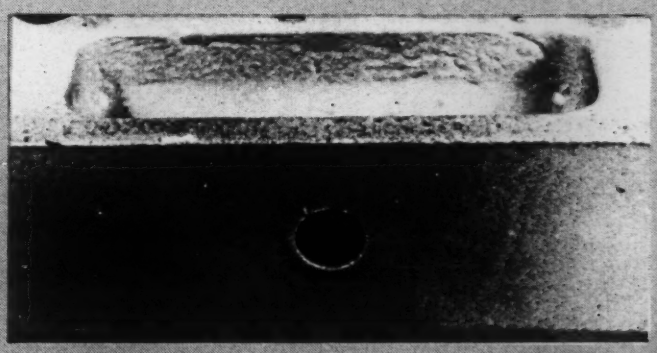
2. *Reliability of procedures* used thus far. Of the various procedures for developing a machine component, those involving tests under actual or simulated service conditions can provide a high degree of reliability. Procedures which do not involve these tests may be less reliable. The reliability of the methods of stress analysis has been discussed previously and some discussion of testing procedures will follow.

3. *Factor of safety* allowed for unknowns and omissions in the development procedure. A factor of safety is selected to provide for variations in material properties (from specifications or with time and environment) and for erroneous assumptions (particularly loading) and omissions (such as residual stress) in a stress analysis all of which lead to the incorrect evaluation of a member's ability to withstand service loading without failure. A factor of safety can be chosen realistically to provide for variations in materials (provided suf-

With this test setup, the service loading of the beam could be simulated and observations of strain made with both brittle lacquer and electric resistance strain gages (SR-4)



Brittle-lacquer analysis showed the ribs and the ¾-inch hole to be stress raisers. (Ribs were originally specified to resist loading applied on assembly by the U-bolts.) Pattern indicated applied load of 6709 pounds produced apparent tensile stress of 24,000 psi. Rating of the steel was 40,000 psi yield strength and 65,000 psi tensile strength. Therefore, yielding of the beam would likely start at a load of 6709 (40,000/24,000) = 11,200 pounds and failure at 6709 (65,000/24,000) = 18,150 pounds, which fall far short of the intended load rating of 20,000 pounds



ficient data exist) but there is no rational method for choosing a factor of safety to provide for the unknowns and omissions in a stress analysis unless some correlation exists between the present design and similar ones which proved successful in the past. Experience and judgment are important assets when the factor of safety is selected. The more unknowns and omissions covered by the factor of safety, the less reliable the design is likely to be. Greater refinement will provide greater reliability.

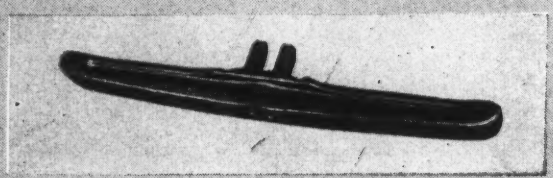
4. *Possible sources of trouble* given adequate attention. Failures often result from overlooking or giving insufficient attention to weak spots caused by stress concentration, residual stress, etc. Also it is important to remember that most failures occurring in the field result from fatigue, impact or creep phenomena. Refinement of a member includes searching out all the possible weak spots so that all portions of the member can be made equally strong.

Another reason why refinement of a machine member may be undertaken is to limit the excess material associated with an extra strong member to a more desirable or necessary maximum. Sufficient strength can be obtained upon the basis of an inadequate analysis merely by selecting a sufficiently high factor of safety. The difficulty with this approach is that extra material accompanying an overdesigned (extra-strong) member sometimes cannot or will not be tolerated. An airplane structure, for example, cannot be designed with a comfortably high factor of safety because excessive weight reduces pay load and hinders performance. As a result the aircraft designer utilizes a highly refined design procedure for insuring a high but safe static strength to weight ratio for his structures and is currently seeking (along with others) an equally refined and effective approach to dynamic loading.

In addition to strength-weight limitations on overdesign, merely weight alone may be undesirable, particularly in high-speed machinery where excessive weight in moving parts leads to higher inertia and dynamic loads. Space limitations may make the increased size and bulkiness of an overdesigned member undesirable. Overdesign also leads to uneconomical use of material; increased fabrication costs; increased handling costs in the form of freight charges, plant space and production flow; and may result in designs of less sales appeal on a competitive market because of greater bulkiness and weight. Upon occasion, however, the more refined product has suffered simply because it did not "look" strong enough to the customer.

Because the ribs were stress raisers as well as points of some difficulty in foundry operations, they were machined away and a strain gage analysis conducted. The test showed the stress distribution was somewhat improved and the load capacity of the beam was essentially unaltered. With the ribs proved unnecessary, actual redesign could now proceed

This is the redesigned casting. Besides removal of the ribs, changes included (1) thickening of bottom tension member from ½-inch to 1⅛ inches, with a tapering down to ¾-inch at the ends; (2) reduction in width of top compression member, except in region of U-bolts; (3) increasing of web section around the ¾-inch hole from ½-inch to 1½ inches, with the increased section blended back into the ½-inch web



Compared with the foregoing arguments, there are certain economic factors which tend to make overdesign appealing and which limit the refinement of a machine member. These factors are:

1. *Money available:* More expense is incurred by using procedures capable of greater refinement.
2. *Talent available:* Outside talent may be required for extensive theoretical or experimental analysis.
3. *Time available:* The necessity or desire to get a product on the market and an early return on the investment will reduce the time devoted to refined development.
4. *Quantity produced:* Large quantity production will more likely absorb the cost of extensive refinement whereas small quantities would perhaps warrant refinement of only certain critical members.

These factors may make the institution of a development procedure economically undesirable from the standpoint of the design at hand, but the possibility of future use should not be overlooked. An analysis too refined to be economical for one design may be economical from the long range point of view.

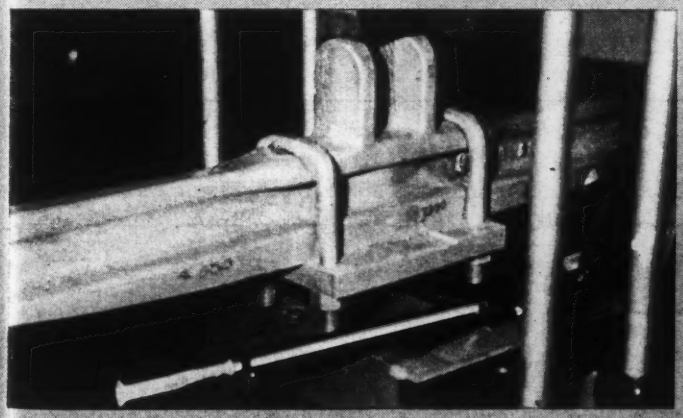
Any of the factors mentioned may be decisive in extending or limiting refinement, or it may be necessary to weigh each of the factors in order to arrive at a reasonable decision.

STRESS ANALYSIS IN DESIGN

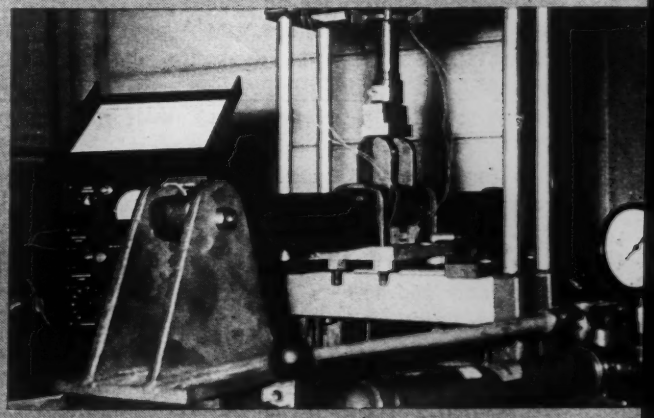
Planning a Development Procedure

An objective of any development procedure is to obtain the required degree of refinement as economically as possible. A satisfactory development procedure may consist of merely the elementary analysis utilized in the initial development or may consist of a combination of paper and pencil and experimental methods of stress analysis together with various tests. Any method proposed for inclusion in a development procedure must be reviewed to insure that the required results can be obtained. The possibilities and limitations of the experimental and paper and pencil methods discussed previously will be of use in this regard. The proposed method must then be evaluated in regard to the mentioned economic considerations. The method finally chosen should be the one which

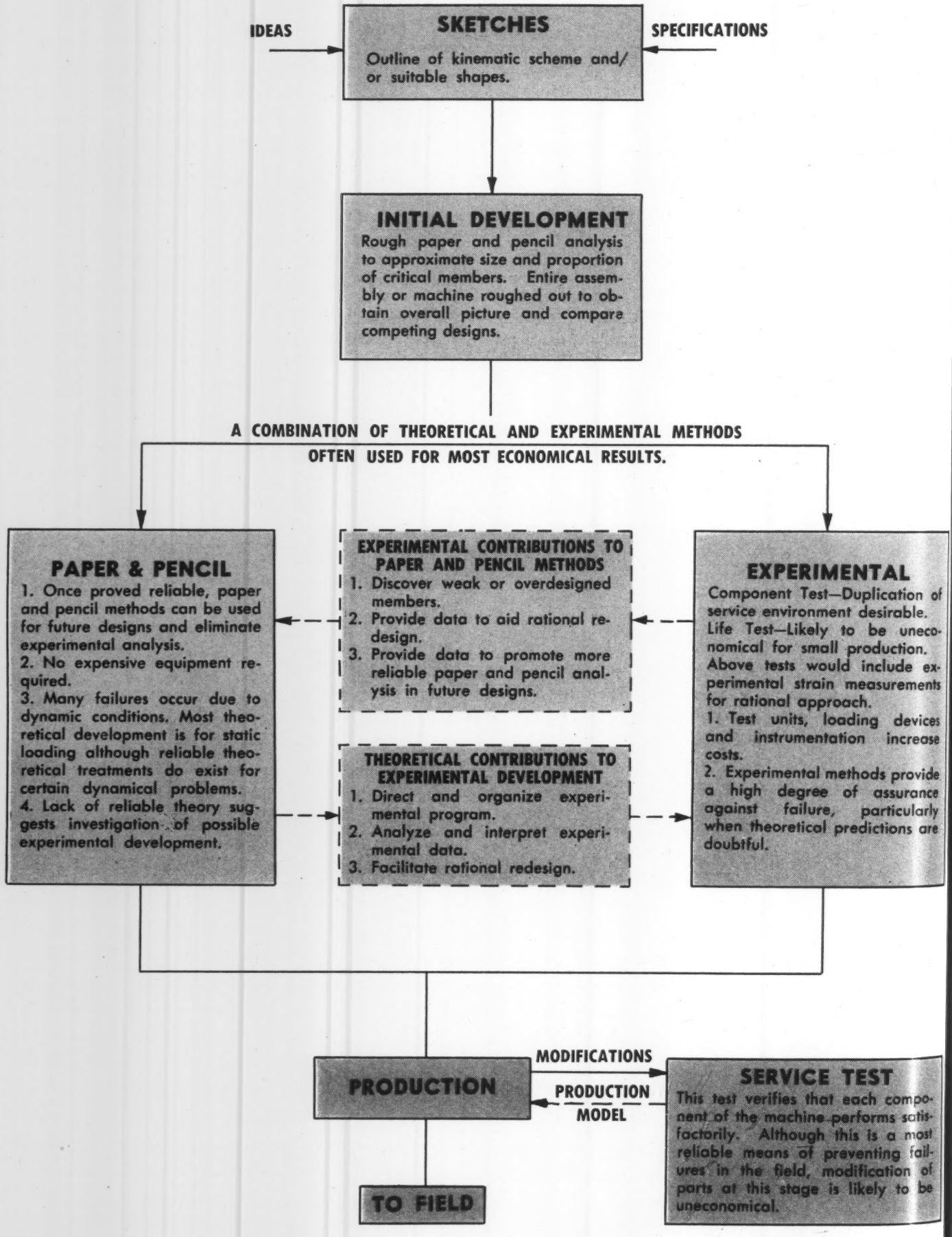
Stresscoat analysis of the redesign showed, for a load of 6709 pounds, apparent tensile stress of 10,500 psi, a substantial reduction from the original of 24,000 psi. At 8946 pounds, the pattern had spread out along the bottom member, indicating favorable distribution of stress, although highest stress was still evident near the ¾-inch hole



Strain gage analysis in the region of the hole showed stress reductions ranging from 42 to 58 per cent, as compared with observations made on the original design with the ribs machined off. On the basis of the highest observed stress, load capacity at yielding was computed to be 25,900 pounds, and at failure, 42,500 pounds—now more than twice the service rating of 20,000 pounds. Weight was reduced by 3 pounds and producibility was improved



A TYPICAL DESIGN DEVELOPMENT PROCEDURE



most nearly satisfies the objective. Because the procedure used to develop a machine part will depend upon the particular member itself, no general procedure can be given. Certain aspects which may or may not recommend various methods of analysis or testing, together with probable contributions resulting from their inclusion in a development procedure, will be indicated.

Paper and Pencil Methods: Because paper and pencil methods require no expensive equipment, they have an initial economic advantage over experimental methods. Detailed searches and investigations can take considerable time, however, which will contribute to costs. An advantage of theoretical or empirical methods is that once they are proved reliable, they can be used for future designs whereas experimental data generally apply only to the particular member at hand.

In general, it would prove most economical to use theoretical methods as long as they are reliable enough to give the requisite degree of refinement. Unfortunately most theoretical development has been restricted to static loading, both in the evaluation of stress and in the theories of failure. Although static strength is necessary, it is not sufficient to insure strength under conditions of dynamic loading. Also it is relatively simple to subject each production model to static overload. Both these factors — reasonably adequate theory and relatively simple static tests — account for the rarity of field failures due to static loading. Most failures can be attributed to fatigue, impact, or creep. Although considerably more is to be expected from theoretical analysis for static rather than dynamic loading, those methods available and under investigation for analyzing the latter should not be ignored. Experimental methods should be considered after it has been decided that paper and pencil methods are not reliable enough to give the desired refinement.

Theoretical Aids to Experimental Development: Data must be analyzed and interpreted if they are to be useful in properly modifying a machine member. Theoretical methods are employed both for analysis (strain rosette and stress-strain relationships, for example) and for interpreting experimental data. As an example of the latter application of theory, consider that a state of stress has been determined based upon experimental strain gage measurements. The significance of this "measured" stress state must still be referred to some criterion of failure before the strength of the member can be appreciated. This criterion might be one of the theories of failure. (It also might be empirical failure data such as represented by *S-N* curves in the case of fatigue, or allowable load tabulations for complicated panels, etc.) There is little experimental work which does not involve some theoretical aspects of a qualitative and usually of a quantitative nature as well. In addition to the analysis and interpretation of experimental data,

1. Theoretical analysis is required in developing a reasonable experimental prototype. The refinement obtained in this development will influence the necessity for or the extent of future experimental modification.
2. Once experimental data have been analyzed and interpreted, theoretical methods may be of considerable use in redesigning a faulty member.
3. Theoretical knowledge (or rather knowledge of the shortcomings of theory which is equally important) helps the designer determine which members will require experimental development due to inadequate theory.
4. Theory aids the designer in predicting probable weak spots and modes of failure thereby insuring that the proper test is made and suitable data taken.

In general it may be stated that a theoretical foundation must direct and organize any experimental program for the most beneficial and economical results.

Experimental Methods: A suitable means for testing the prototype is essential to any experimental development program. "Component testing" is the name given to one method in which a member or an assembly of components is tested under actual or simulated service conditions possibly during or before construction of the entire machine. The most probable difficulty in component testing is the duplication of service environment during the test. It is particularly important that the loading in the test be the same as that encountered by the component under actual operating conditions. Often the service loads are not known with sufficient accuracy or are extremely difficult and costly to duplicate. Such a situation exists in the case of the random loads contributing to cumulative fatigue, for example. One precaution which should always be observed in any experimental development program is to avoid accepting static or short-term test results as adequate indications of strength when fatigue may be the controlling mode of failure. Fatigue tests may be properly scheduled as part of an experimental development procedure.

"Life testing" provides another kind of experimental test. In this method, the machine is actually constructed and tested under actual or simulated service conditions. Any members which fail may be investigated and modified until a satisfactory component is obtained. This method of development is likely to be uneconomical and hence can be justified only if large scale production is anticipated. If a suitable component test is possible, it could normally be expected to provide results more economically than the life test.

By means of component or life tests, it can be determined whether or not a member has been properly designed. If a member fractures or buckles, it obviously was faulty. Other modes of failure such as excessive elastic deflection or plastic deformation may not be as apparent and may require use of experimental stress analysis techniques for their detection. Without the aid of experi-

mental stress analysis it would be difficult to locate over-designed components. Once failure or over-design has been discovered, means for modifying the improperly designed part must be considered.

One method of modifying weak members is simply to make them heavier in the regions of failure, test them again, and if they do not fail consider the program a success. Although this is not a rational nor elegant procedure it can frequently produce a safe member. Valid objections to the method lie in the facts that aside from discovering the mode of failure not much has been contributed toward improving an obviously deficient development procedure preceding the test; and, if fatigue is the cause of failure, this trial and error method may require too much time before results are obtained. Sometimes, too, a stronger member may be produced by the removal of material, a result not likely to be realized by any rough-and-ready procedures.

A more rational method of modifying parts is to secure data by the methods of experimental stress analysis which will lead to more logical modifications. For purposes of development, experimental stress analysis methods may be thought of as contributing significant data which when properly analyzed and interpreted by theoretical methods, may be useful in discovering and properly modifying not only weak members but also overdesigned components. It also may be used to advantage in investigating members which perform satisfactorily in order to verify theoretical techniques. Brittle lacquers applied to a suspected member will uncover the weak or strong regions after which gages may be used to measure the strains. These methods are relatively simple to use and are well adapted for use on the testing floor. If sufficient or reliable data cannot be obtained by these methods, then X-ray, photoelasticity, or analogy methods, which are most commonly found in the research laboratory may provide suitable information. In planning an experimental program, the possibilities and limitations of each method (such as discussed in part 3 of this series) must be recognized so that the proper data will be secured in the least time.

Component and life tests become expensive methods of development because they require fabrication of test pieces, possibly construction of loading devices, and instrumentation for making measurements together with the time and talent needed to carry out the test program. They can provide a high degree of assurance against failure for important members whose failure involves considerable risk and whose development is too complex to be reliably treated by theory alone. These methods also provide excellent means for refining a design whenever quantity production justifies the expense.

In planning an experimental program, the possible contributions an experimental investigation can make to paper and pencil methods should not be overlooked. Once a reliable theory exists to analyze a particular problem, there is no more need for experimental investigation of that problem. Possible contributions include:

1. *Verification of theoretical assumptions or procedures.* Experimental analysis of a member performing satisfactorily in service may justify use of the pertinent theoretical procedure in the future.
2. *Exposure of weak and over-designed members.* Such discoveries may lead to modification of theoretical assumptions and methods.
3. *Provide data for a reliable theoretical analysis.* Such pertinent information as service loads, stress concentrations, and residual stresses may be investigated experimentally and tabulated for future theoretical use.
4. *Provide data upon which to base an empirical procedure* (where no rational method exists).

Service Test: The most certain way of preventing failures in the field is to build one or several of the new machines before any are sold and subject them to actual or simulated service conditions for a period of time equivalent to their life span if possible. The latter stipulation is included to prevent acceptance of static or short term test results as indications of strength when fatigue or creep may be the controlling mode of failure. Such a test is called a "service" test to distinguish it from the life test whose primary purpose is development. The purpose of a service test is to verify that each component of the machine has sufficient strength and in fact all other properties necessary to insure proper performance in service. This test should be made on any new or modified product whenever possible in recognition of the fact that both the methods of development and the designer are fallible. Small quantity production, particularly of large machinery, may preclude a service test.

Although a service test is made to uncover weak members, failures and the engendered modifications at this stage of development are most undesirable because of economical aspects. Changes are likely to be extremely costly, particularly if modification of one part enforces modification of adjoining parts due to space, functional or loading considerations. If unforeseen changes are made, tools, dies, fixtures and other production equipment may have to be modified or even scrapped because these items are often made from the blueprint before any testing is done. In fact, the first production units often serve as test specimens. To management, modification means additional capital and overhead expense and a longer time before the investment is recovered.

REPRINTS

To satisfy the high demand for extra copies of "Stress Analysis in Design," this four-part 40-page series is being reprinted in pamphlet form. Copies may be obtained for $1.00 each from Reader Service Dept., MACHINE DESIGN, Penton Building, Cleveland 13, O.

APPLYING ECCENTRIC GEARING

. . . to meet unconventional linear and angular motion requirements with standard mechanisms

By Paul Grodzinski
London, England

PRINCIPLES and design of eccentric gear mechanisms have been treated in detail in a previous article.[1] Consisting of circular spur gears mounted on eccentric axes, these mechanisms provide a convenient and practical method for producing a wide variety of nonuniform angular motions. Noncircular gears, linkage systems or other devices will usually give equivalent results, but, in many instances, the use of some form of eccentric gearing offers definite advantages, not the least of which are low cost and, often, simplicity.

In this article, attention will be devoted to some of the more important applications, both tried and possible, of these useful devices. Methods of adapting eccentric gearing to standard mechanisms to meet specific motion requirements will be demonstrated and analyzed.

Cross-Slide Mechanism: For conversion of rotary

[1]References are tabulated at end of article.

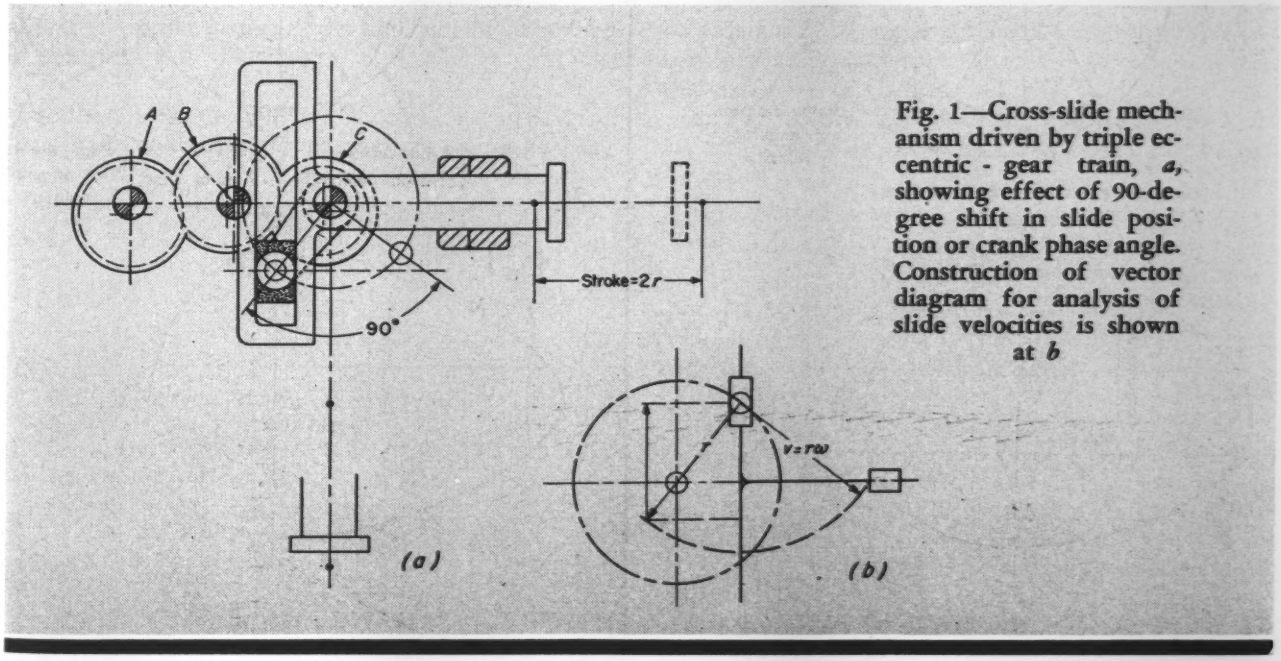


Fig. 1—Cross-slide mechanism driven by triple eccentric - gear train, *a*, showing effect of 90-degree shift in slide position or crank phase angle. Construction of vector diagram for analysis of slide velocities is shown at *b*

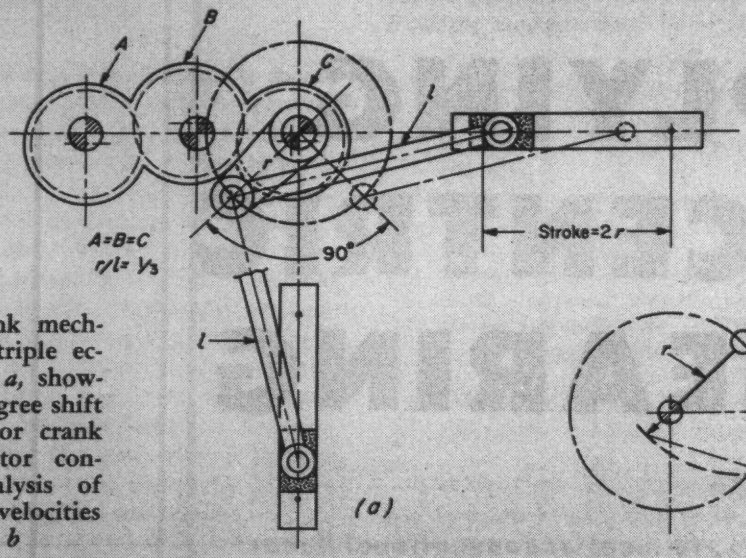


Fig. 2—Slider-crank mechanism driven by triple eccentric-gear train, *a*, showing effect of 90-degree shift in slide position or crank phase angle. Vector construction for analysis of crank and slider velocities is shown at *b*

Fig. 3—Angular velocity diagram of crank and velocity-displacement pattern of slider for a slider-crank mechanism driven by double eccentric-gear train. Slide is perpendicular to axis of gear train and center of driving gear is in extreme left-hand position when crank is at polar station 3

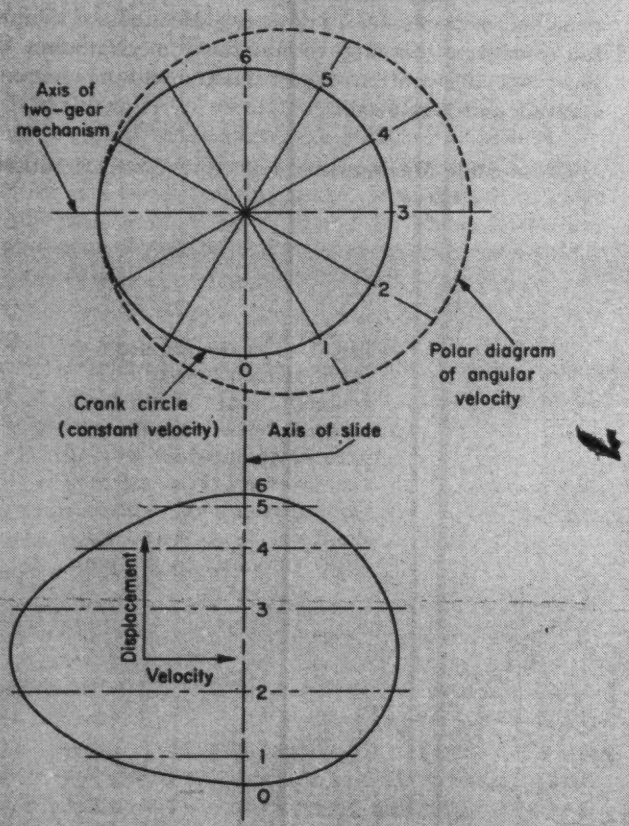
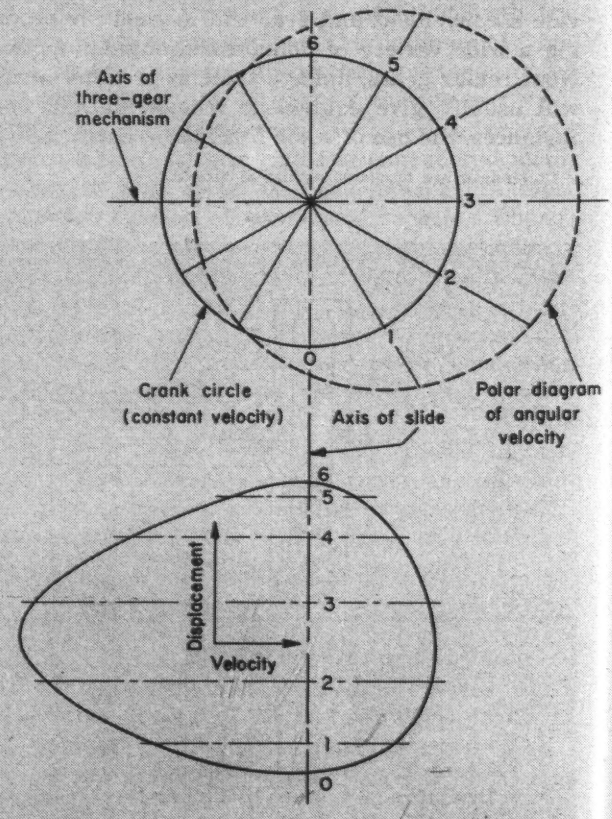


Fig. 4—Angular velocity diagram of crank and velocity - displacement pattern of slider for mechanism shown in *Fig.* 2. Slide is perpendicular to axis of gear train and center of driving gear is in extreme right-hand position when crank is at polar station 3



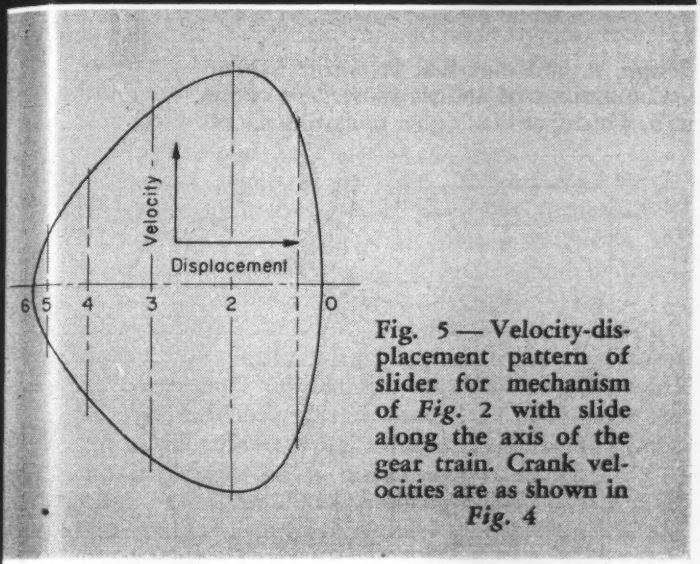


Fig. 5 — Velocity-displacement pattern of slider for mechanism of *Fig.* 2 with slide along the axis of the gear train. Crank velocities are as shown in *Fig.* 4

into reciprocating linear motion, the cross-slide driven by a triple eccentric-gear train, *Fig.* 1, offers a simple but effective combination. At an eccentricity of $0.1R$, where R is the radius of each gear in the train, results closely approximating those obtained with noncircular gear arrangements are possible. Equivalent performance could also be achieved by another form of eccentric gearing, the reverting gear train,[1] which offers the advantages of a more compact arrangement.

A useful graphical construction for analysis of sliding velocities is shown in *Fig.* 1*b*. Crank velocity may be determined from $V = r\omega$, where V is the velocity, r is the crank radius and ω is the instantaneous angular velocity of the driven gear.

Because of the close similarity in performance of the cross-slide and slider-crank mechanisms, differing only by the effect of the finite length of coupler rod, many of the considerations applying to one are equally applicable to the other. For purposes of analysis, the slider-crank appears to be more representative of the general case and will be examined in detail.

Slider-Crank Mechanism: A triple eccentric-gear train driving a slider-crank and the corresponding graphical velocity construction are shown in *Fig.* 2. An eccentricity of $0.1R$ for each gear is assumed and the ratio of crank radius to rod length is $r/l = 1/3$ throughout.

In contrast to the cross-slide mechanism, velocity diagrams of the slider will be slightly asymmetrical due to the effect of the finite length of the coupler rod. However, modification of the velocity-displacement characteristics of the slider can be obtained by (1) shifting the line of action of the slider angularly in relation to the center line of the eccentric gear train or (2) changing the position of the crank with respect to the eccentric axis of the driven gear. These effects are demonstrated in *Fig.* 2*a*. As indicated by the dotted lines, for a given position of the gear set, rotation of the crank through an angle of 90 degrees has the same effect as rotation of the line of action of the slider through the same angle in the opposite direction.

Both of the foregoing principles, separately or in combination, can be used to advantage in design. For example, the most suitable velocity-displacement relationship may be "selected" by positioning the slider line of action or a closer regulation of slider action may be provided by adjustment of the crank phase angle. The equivalent effects of these adjustments for the cross-slide mechanism are shown in *Fig.* 1*a*. In the following discussion only the slide adjustment is considered.

Polar diagrams of angular position versus angular velocity for the crank and velocity-displacement relationships for a slider operating at 90 degrees to the centerline of the gear set are shown for a two-gear train in *Fig.* 3 and for a three-gear train in *Fig.* 4. In each case, the polar diagram of angular crank velocity is symmetrical about the center line of the gear set but nonsymmetrical about a line at right angles. Thus, if a slow approach and quick return are required, the slide line of action should be as shown. If equal speeds for approach and return are desired, the line of action should lie along the centerline of the gear set, *Fig.* 5.

In *Fig.* 3, the relationships shown are based on an eccentricity of $0.1R$, and in position 3, the ec-

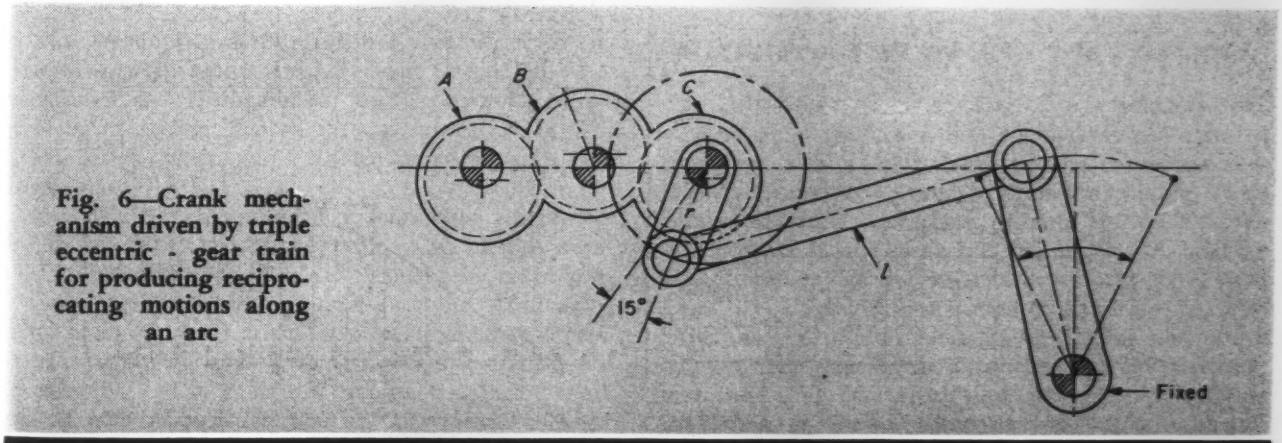
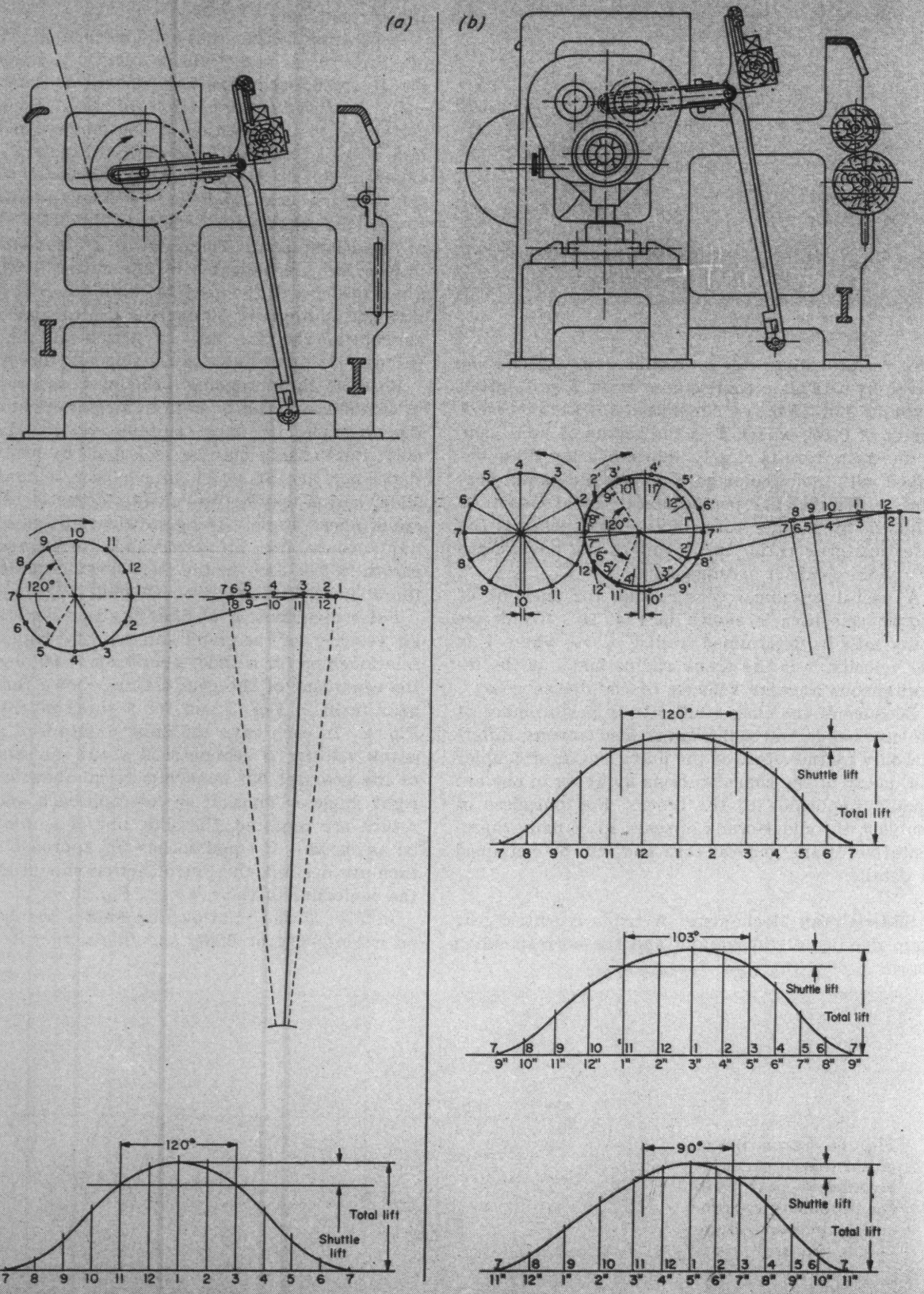


Fig. 6—Crank mechanism driven by triple eccentric - gear train for producing reciprocating motions along an arc

Fig. 7—Conventional four-bar linkage design, *a*, and modified eccentric gear arrangement, *b*, for a weaver loom drive. Comparison of shuttle movement curves illustrates improved lift action of redesign, *b*, which permits higher operating speeds



centric axis of the driven gear lies along the center line of the gear set. As indicated by the velocity diagram, slider velocity in one direction is essentially the same as that for a uniform crank rotation while in the opposite direction a velocity increase of about 1.5 times is obtained.

The increased velocity variability afforded by the triple eccentric-gear train is clearly indicated in *Figs.* 4 and 5. For the slide position of *Fig.* 4, the velocities in the two stroke directions as compared to a uniform velocity crank drive would be in the ratios of 1/1.2 and 1.87/1. For the slide position of *Fig.* 5, velocity variations would be equivalent for both stroke directions. Starting velocity would be slow, accelerating to a maximum value near the end of the stroke, with a rapid deceleration at the end position. At a displacement of 0.9 of full stroke, the ratio of the velocity reached to that of a uniform velocity crank drive for the same slider position would be about 1.6/1.

Modifications of the arrangement of *Fig.* 2 can also be used to advantage in meeting specific problem requirements. By providing an additional gear reduction of 2/1 between the crank and the driven gear, a constant velocity slider motion in both stroke directions can be obtained. This mechanism can also be used with a cross-slide for the same results. Details of the mechanism have been described in another article.[2]

Special Mechanisms: Instead of linear sliding motion, a swinging arc movement can be developed by connecting the coupler rod to a fixed link, *Fig.* 6. Both uniform and varying velocity reciprocating motions along an arc can be obtained with this mechanism.

Table 1—Comparison of Weaver Loom Drives

Drive	Shuttle Movement (degrees)	Lift/Total Lift
Conventional four-bar linkage.....	120	0.21
Double eccentric gear		
Standard crank position	120	0.163
Crank advanced 60 deg	103	0.148
Crank advanced 120 deg	90	0.116

Cam mechanisms offer another area in which the adaptation of some form of eccentric gearing may be beneficial. Extension of dwell positions or reduction of speeds in passing cam ramps are typical possibilities which can lead to improved cam performance.

For all of the standard mechanisms discussed, other forms of eccentric gearing[1] also offer a number of possibilities. The reverting gear train previously mentioned is a typical example. Additionally, investigations with an experimental mechanism have shown that eccentricities up to 0.2*R* are permissible with carefully designed gears. This would act to increase the velocity variability of the double-gear train, extending its usefulness to a number of applications previously considered impractical.

Recent Developments: A practical application of eccentric gearing to a recently developed drive for a weaver loom is shown in *Fig.* 7. Replacing a conventional four-bar linkage arrangement, *Fig. 7a,* the new design incorporates a double eccentric-gear train, *Fig. 7b.* Facility of adjustment, a consideration of special importance in this case, as well as general performance characteristics have been improved by the redesign.

A comparison of the characteristics of the two drives can be obtained from shuttle movement curves in *Figs. 7a* and *b.* For the conventional design, *Fig. 7a,* a lift of 21 per cent of the total lift is obtained at the far end position during a shuttle movement of 120 degrees. In the new design, *Fig. 7b,* use of the double eccentric-gear train (0.1*R* eccentricity) permits the speed of the lay to be reduced as the shuttle passes, decreasing the lift to about 12 per cent of total for a 120-degree movement and minimizing stresses in the warp threads. A further advantage is that changes in lift can be readily obtained by advancing the phase angle of the crank; shuttle movement is not hindered and the warp threads are opened quicker. Actual results obtained with the new drive indicate that shuttle operating speeds can be increased 20 to 25 per cent without increasing member stresses. Performance characteristics of the conventional and modified drives are compared in Table 1.

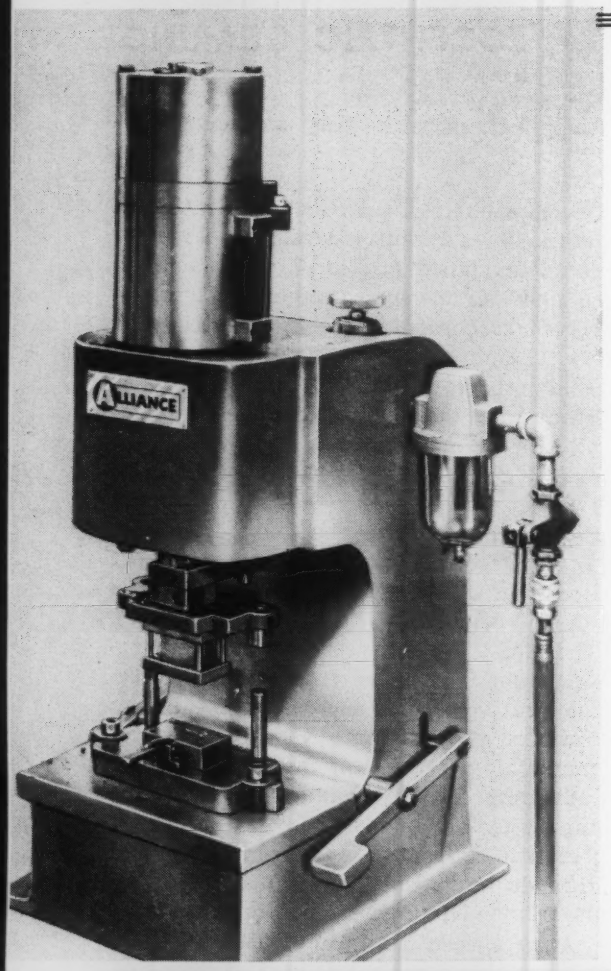
The importance of gear mechanisms for producing varying angular velocities in semiautomatic and automatic machines is apparent. For many of the problems encountered, the circular gear mounted eccentrically with its inherent simplicity may well prove to be an efficient solution.

REFERENCES

1. P. Grodzinski—"Eccentric Gear Mechanisms," MACHINE DESIGN, Vol. 25, No. 5, May 1953, Pages 141-150.
2. P. Grodzinski—"Mechanisms for Uniform-Velocity Reciprocating Motion," MACHINE DESIGN, Vol. 26, No. 2, February 1954, Pages 141-145.
3. E. A. Pawelka—"A Lay Drive With Automatic Acceleration of the Warp Opening," *Oesterr. Maschinenmarkt* (Austria), Vol. 17, 1952, Pages 495-498.

Miniature Bearing Improves Balance

ACCURATE construction of a miniature ball bearing used as a cam follower in a Voland & Sons Inc. analytical balance is said to permit sensitivity in operation not previously available. Total indicator runout of the bearing is 0.0002-inch which permits the push rod on which the bearing is mounted to lift the balance beam only 0.001-inch from its knife-edge mounts. This small lift assures accurate alignment of the beam and knife edges when the beam is released. The bearing, manufactured by Miniature Precision Bearings Inc., has a major diameter of 0.250-inch and mounts on a 0.0791-inch shaft.

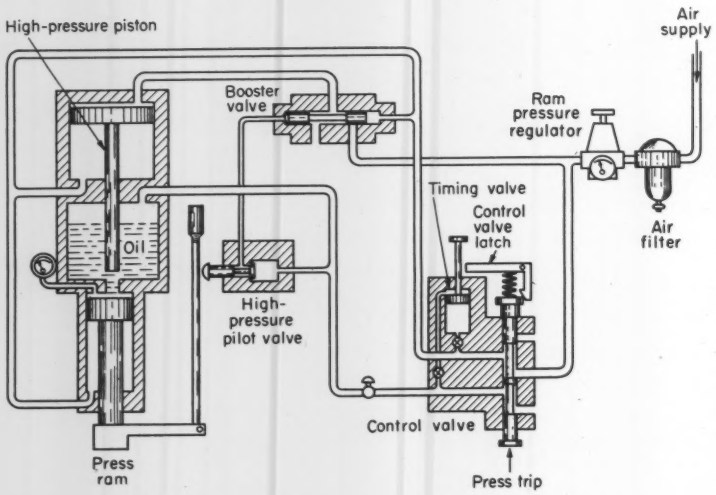


Air-Hydraulic Press Has Double Pressure System

DEVELOPING 5 tons ram pressure when connected to a 100 psi air line, the new Model 500 Pnu-draulic bench press operates on a dual pressure system. The ram of the Alliance Mfg. Co. press is lowered and raised by relatively low air-line pressure, with high pressure kicking in only during the short distance necessary to perform the press operation. Weighing only 300 pounds, the press can be attached to any shop air line, and is easily moved. Air consumption averages ¼-cubic foot per stroke, and stroke is adjustable from 0 to 3 inches.

When the control valve is tripped, line air pressure is applied to the oil chamber above the press ram. Control valve spool is held in the *up* position by a latch. When the press ram nears the bottom of its stroke, a high-pressure pilot valve is opened, opening a booster valve and permitting line air pressure to be applied to the high-pressure piston. For the remainder of the stroke, the ram is actuated by straight hydraulic pressure developed by the high pressure piston. When maximum pressure is reached (ram is stopped), a check valve in the control valve lifts, and line pressure is applied to the top of a piston in the timing valve. In its bottom position, the timing piston trips the control valve latch, allowing spring pressure to return the control valve spool to its initial position. Air pressure then returns the ram, high pressure piston, booster valve spool and timing valve piston to their initial positions. One obvious advantage of the system is that, in case of a press jam which prevents the ram from reaching its normal operating position, the high pressure operation is not initiated.

CONTEMPORARY DESIGN



Designing Stable Polygon Cross-Sections for PRESSURIZED STRUCTURES

By B. Saelman
Lockheed Aircraft Corp.
Burbank, Calif.

PRESSURIZED structures are encountered in many areas of design engineering. For example, in aircraft, hydraulic reservoirs are often pressurized so that sufficient head will exist at the pumps at any altitude. Also fuel tanks must be designed to withstand fuel pressures, ram vent pressures and pressure differentials between internal and external air pressure. In this area of design it is practically always necessary to determine the minimum weight structure possessing proper strength requirements. Design techniques for minimizing weight of pressure vessels in all areas of machine design are quite important because additional or excess weight usually adds to the cost. This data sheet presents methods of determining optimum design in shape and weight of elementary and complex pressure vessels with polygon cross-sections.

Weight and Shape Factors: Although the sphere is the minimum-weight pressurized structure for a given volume, this shape is seldom employed because of clearances, available space, fabrication costs, etc. Therefore, flat-sided (polygon cross-sectioned) pressure vessels are sometimes used where design situations warrant. However, care must be exercised in the selection of the cross-sectional shape of such structures. While a certain multisided vessel design might conveniently fit into an available space or cavity, the unit might tend to deform under pressure; thus weight would need be added in bracing the structure sufficiently for stabilization.

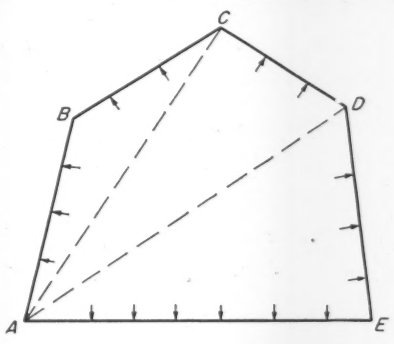


Fig. 1—Cross-section of flat-sided pressure vessel

If the flat-sided tank shown in cross-section in *Fig.* 1 is an unstable shape and the sides are free to pivot about their vertices, the tank will deform under pressure until it assumes maximum possible volume, neglecting the tendency of the sides to diaphragm. This phenomenon occurs because of the fundamental equation $E = p\,(V_{max} - V)$ where E is potential energy, p is internal vessel pressure, V is any volume enclosed by a particular vessel shape, and V_{max} is the maximum volume that can be enclosed by this same vessel. Thus a pressure vessel with a polygon cross-section is stable when E is a minimum or when $V = V_{max}$. Therefore, when $V \neq V_{max}$ in *Fig.* 1, the vessel shape is unstable under pressure. Bending moments must be carried across the joints; tension ties, AC and AD, and/or corner reinforcements would be needed to prevent deformation. Thus, for given side lengths and sequence, the cross-section enclosing maximum area is stable and weight would be saved with such a design since tension ties and/or corner reinforcements would not be needed.

Stable Polygon Shapes: Those flat-sided structures with symmetrical cross-sections such as equilateral triangles, squares, and all other equiangular, equilateral polygons which enclose maximum volume are always stable. Of course, triangles are stable whether symmetrical or not. It is obvious in symmetrical polygons that the perpendicular bisectors of the sides intersect at a common point and the vertices are concyclic. It is also true that any nonsymmetrical polygon, with four or more sides, is stable and encloses maximum area when the perpendicular bisectors of the sides are concurrent, which is a necessary and sufficient condition for the vertices to lie on a circle.

Stable Polygon Design: Several methods of at-

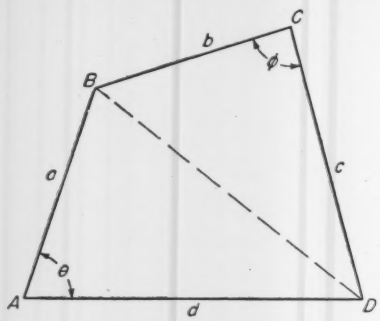


Fig. 2—General quadrilateral cross-section

tack including calculus can be employed to design stable polygon shapes for given side lengths and sequence. Usually direct construction techniques are unknown. However, trial and error procedures, either analytical or graphical, will often quickly lead to a stable shape solution. Trial and error approaches should make full use of the theorem that if the perpendicular bisectors of the sides of a polygon are concurrent, the vertices are concyclic.

For any quadrilateral, *Fig.* 2, it can be shown that

$$A = \tfrac{1}{2}\,(ad \sin\theta + bc \sin\phi) \quad \ldots\ldots (1)$$

where A is polygon area. This quadrilateral would be stable by finding A_{max}. It is known from differential calculus that a function is maximized when values for the unknowns make the first derivative equal to zero and the second derivative equal to less than zero. In this case it can be shown that $A = A_{max}$ when $\theta + \phi = \pi$ radians. Since

$$(BD)^2 = a^2 + d^2 - 2\,ad \cos\theta = b^2 + c^2 - 2\,bc \cos\phi \quad \ldots\ldots (2)$$

substitution of $\phi = \pi - \theta$ into Equation 2 and transposition of terms gives

$$\cos\theta = \frac{a^2 - b^2 - c^2 + d^2}{2\,(ad + bc)} \quad \ldots\ldots (3)$$

or

$$\theta = \cos^{-1}\left[\frac{a^2 - b^2 - c^2 + d^2}{2\,(ad + bc)}\right] \quad \ldots\ldots (4)$$

This value of θ gives maximum polygon area and thus a stable design shape. A given value of θ automatically fixes figure shape since a four-sided polygon has only one degree of freedom. Incidentally, Equations 3 or 4 have real solutions for θ only when the value of the bracketed quantity in Equation 4 is between -1 and $+1$. Also area A of any quadrilateral is given by

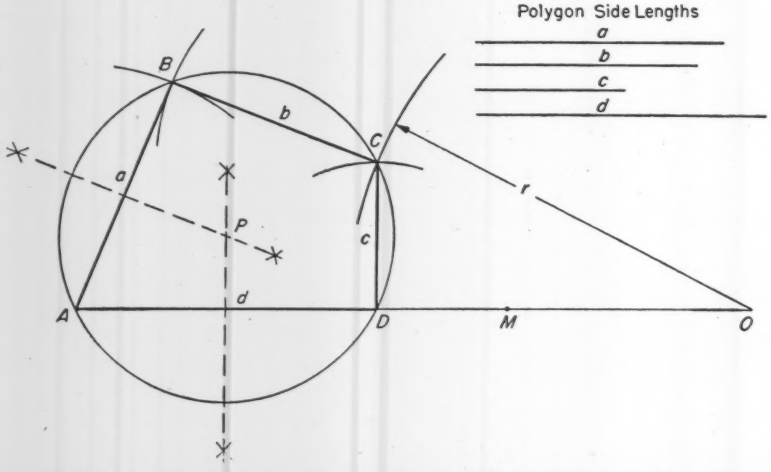
$$A = \sqrt{(s-a)(s-b)(s-c)(s-d) - abcd\cos N} \quad \ldots\ldots (5)$$

where $s = \tfrac{1}{2}(a+b+c+d)$ and $N = \tfrac{1}{2}$ the sum of one pair of opposite angles.

Concyclic quadrilaterals can also be constructed by a geometric approach when each side length is given by a method outlined in *Fig.* 3. While a direct construction is possible in the case of a quadrilateral, this is not so for the pentagon and other polygons with more than five sides. With these, a trial and error approach such as previously mentioned is the only reasonably simple solution.

Fig. 3—Analytical construction solution of maximum area quadrilateral for given side lengths and sequence. Solution procedure:

1. Lay off $(AD) = d$, longest given side, and $(DM) = bc/a$.
2. Construct a circle with radius equal to side c with D as center.
3. Construct another circle with radius $r = (AM)\ k/(k^2-1)$ where $k = a/c$ and center O is located on a line passing through ADM at a distance from A equal to $(AO) = (AM)\ k^2/(k^2-1)$.
4. Determine point C by an intersection of two circles constructed in steps 2 and 3.
5. From point C as center, draw an arc with radius equal to side b and from A as center, swing an arc with radius to side a. Intersection of these two arcs determines point B.
6. Construct stable polygon by connecting points A, B, C and D with straight line segments.
7. Check construction accuracy by drawing a circle through points A, B, C and D using as center point P which is the intersection of the perpendicular disectors of any two polygon sides.



Engineering News Roundup

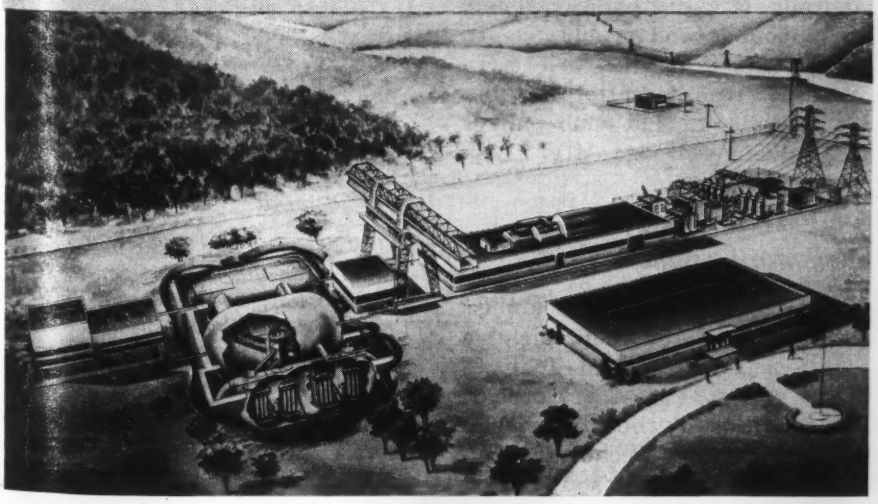
Largest Privately Owned Wind Tunnel to be Built

Largest intermittent blow-down wind tunnel in this country, and one of the largest constructed by private industry, will be built by North American Aviation Inc. at a site near Los Angeles International Airport. With total cost to be over $4 million, the tunnel will be capable of testing airplanes and guided missiles at speeds ranging from 400 mph to more than three times the speed of sound.

Wind speed will be produced by compressed air released from a series of storage spheres. Control of air speeds will be by a method of controlling an adjustable nozzle, a transonic chamber and a variable diffuser, all placed in series in the throat of the tunnel. Adjustments of each of these structures are expected to be made in considerably less time than necessary for like adjustments in other tunnels. Tests will be about one minute in duration. Models with wingspans up to 4 feet will be handled in the tunnel's test chamber.

Complex structural parts of the tunnel will be constructed by the Pittsburgh-Des Moines Steel Co. at its plants and assembled at the construction site. North American estimates the facility will be completed in 1956.

FIRST ATOM POWER PLANT recently proposed by the Duquesne Light Co. (MACHINE DESIGN, May, 1954, Page 191) is shown in this preliminary artist's sketch. Westinghouse Electric Corp. is developing and building the reactor under contract to the AEC. Duquesne Light will design and construct the turbine-generator and operate the plant at Shippingport, Pa. Sketch shows from left to right: fuel handling building, reactor and heat exchangers, maintenance building, with traveling crane, turbogenerator building, switchyard and transmission lines. Building in foreground contains shop and administrative facilities



Industry's Prosperity Due to Engineers' Influence

The prosperity of the nation's larger industries is due largely to the influence of the engineer, Dr. John T. Rettaliata, president of Illinois Institute of Technology, told a management group of the Society for the Advancement of Management recently.

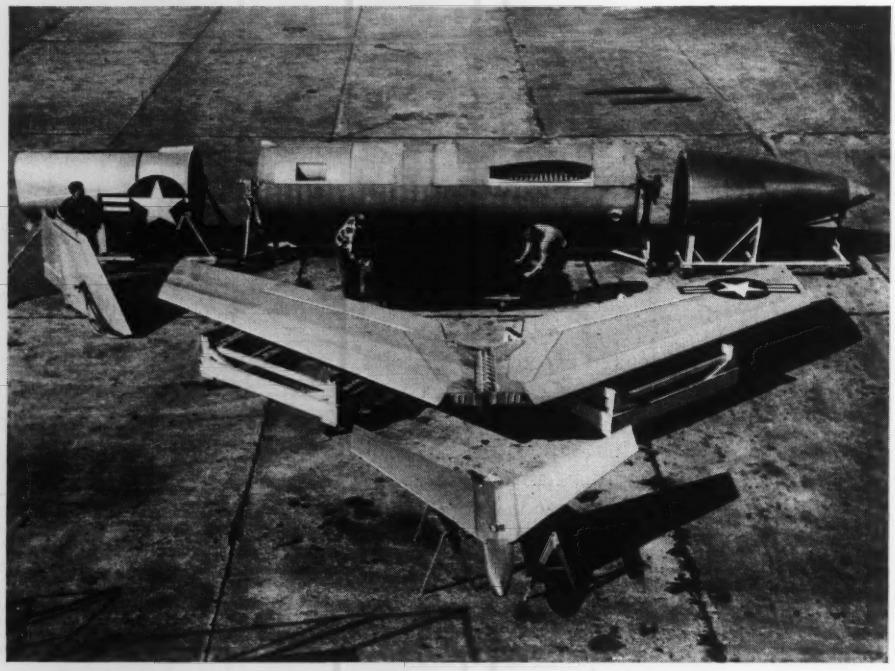
Although engineering colleges constitute only a tenth of all higher educational institutions in the country, nearly half of the major corporations are headed by executives with engineering or scientific backgrounds, Dr. Rettaliata said.

Referring to a recent survey of the executive ranks of the 300 largest corporations, the Illinois Tech president said 30.8 per cent had backgrounds in business economics, while 45.5 per cent were educated as engineers or scientists. The remaining 23.7 per cent were educated in law or the arts.

"Considering the excellent state of corporate health, it must be concluded the engineer has done a good job," he said.

"Do It Yourself" Kit For Guided Missiles Here

Dream or nightmare of model airplane builders is this new king-size "kit" for a full size USAF B-61 Martin Matator. Using a technique developed by Glenn L. Martin Co., the pilotless bomber is manufactured in seven major



Assemblies in which the USAF B-61 Martin Matador is manufactured. These components are weatherproofed and coated for assembly and later use

parts. Each part is shipped in a separate crate, and the unit may be assembled in the field just prior to launching.

Eliminating factory final assembly, this new system is said to provide easier shipment and reduced costs. Units may be stored at their destination and assembled years after their manufacture. Movement from one base to another is facilitated by moving the packaged parts rather than making it necessary to transport a completed bomber.

Sections comprising the assembly are the nose, wing, center section, aft tail, fin and bullet-fairing stabilizer sections, and the instrumentation. Completely interchangeable, no two of the sections have to be made for each other. This standardization has long been a practice in the automotive industry and is now successfully applied to aviation.

Speedwalk in Operation

First passenger conveyor belt in the world (see MACHINE DESIGN, Nov., 1953, Page 188) was recently placed in operation in the Hudson and Manhattan Railroad's Erie tube station. The 227-foot "Speedwalk" can carry 10,800 commuters per hour up an inclined ramp to the Erie Railroad terminal at a speed of 120 fpm although only about 9000 commuters presently use the station daily. The installation was designed and constructed by Goodyear Tire and Rubber Co. and Stephens-Adamson Mfg. Co.

Driven by a 20-horsepower General Electric motor, the 5½-foot wide endless belt has moving handrails, is ⅝-inch thick, weighs 11,000 pounds and is 460 feet in length. Ends of the belt were vulcanized together after installation. Head, tail and snub pulleys were made by Dodge Mfg. Corp.

Study Women, Appliance Designers Told

Today's electric appliances must be engineered to unpredictable conditions, according to John C. Sharp, president of the Hotpoint Co. Speaking at the fifth annual AIEE Appliance Technical Conference recently, he stated that engineering of appliances is the most difficult of all assignments, and to meet this challenge he advised future appliance design engineers to subscribe to college courses in women, color, form, illogic and human relations. "Customers" he said, "are nonscientific and have no desire to become so."

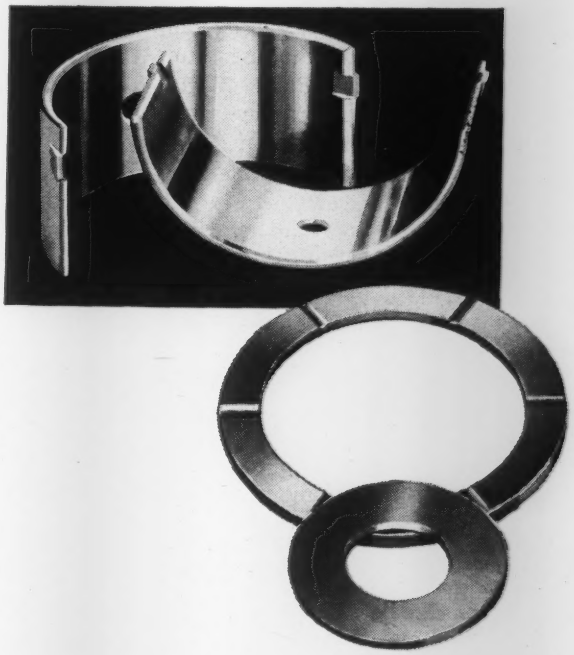
He told the engineers that today's electric appliances must be engineered to unspecified conditions that exist in the American home, such as heat, cold, pressures, vacuums, acids, alkalies and tissues (both living and dead). Among other engineering problems are heating units developed to withstand the deluge of babys' formulas; detergents, used in washing clothes, that destroy aluminum and rubber; plastics which are discolored and attacked by perspiration; cleaning compounds and foodstuffs that make excellent electrolytes, resulting in corrosion where dissimilar metals are used.

Appliance design engineers, in addition, must be able to solve these problems in "three months for 75 cents." Sharp added that if cost requirements are met, the design must be small enough in size and acceptable to the human eye as a piece of furniture. The

"We've dropped it 35 feet . . . laid it on the ocean floor for 6 weeks . . . and let it run 250,000 hours without harm. Now, the final test . . . a typical husband will make a minor adjustment!"

JOHNSON BRONZE • ON • STEEL

BOTH SURFACES



Where "two-side" bearing surfaces are required, Johnson Bronze-on-Steel is the answer. Floating connecting rod bearings often require this type of metal, also thrust washers. They are produced by bonding pre-cast bronze powder* to both sides of steel strip. This combines the fine bearing properties of copper-lead alloy with the strength and other properties of steel. This material is available in bearing form, or in strip form—rolls up to 400 feet or individual strips of any length for your own stamping or forming.

JOHNSON JB BEARINGS
Sleeve Type

* To assure complete laboratory control of quality from the ingot to the finished product, Johnson Bronze has built a new powder plant for the production of alloy type powders by a patented process of disintegrating and quenching molten alloys. Therefore, the correct alloy for a particular use can always be prepared to correct specifications. This is another reason why Johnson Bronze has become known as Sleeve Bearing Headquarters.

Write for information.

JOHNSON BRONZE COMPANY • 525 South Mill Street, New Castle, Pa.

appliance engineer must know when a product is far enough along in development to justify producing and selling it. "It can never be half perfect," he said, "until the engineer knows what the customers are going to do with it."

Performance testing was cited as the most important phase of appliance engineering. Sharp remarked that field tests showing 1 per cent failure are expensive, 2 per cent will slow progress and 5 per cent will "put you out of business." Performance tests must meet four requisites. First, they must obtain results in a reasonable time; second, they must measure the property in question in terms related to actual use; third, the test should be concerned only with a requirement of actual use; and fourth, the standard must be chosen on the basis of a required minimum.

EXTREMELY UNDULATED vanes made this washing machine agitator a difficult molding project. Plastic Service Corp. molded it in a conventional way using a special Durez compound

New Gun Developed From Captured German Design

Developed from a badly damaged fast-firing German machine gun captured near the end of World War II, a new 20-mm cannon called the M39 is now in mass production. Armour Research Foundation, in 1946, was awarded the original contract to develop the weapon and its early work consisted of study and analysis of the design features and operating principles of the German model.

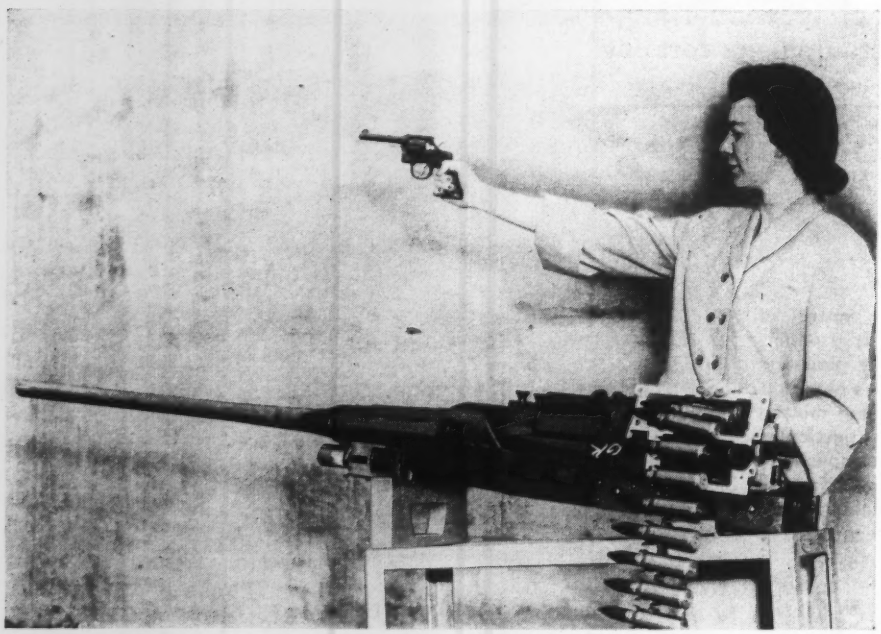
After reconditioning the weapon, Armour engineers obtained preliminary performance data from firing tests. Design and construction of early development models was based upon these preliminary data.

Production development of the weapon was begun by the Ford Motor Co. in 1951 with Armour functioning in a consulting capacity. First of the production guns was built in three months. Improvements in design resulting from continued development were adapted to mass production by Ford.

At the present time, Pontiac Motors Div. of General Motors is producing the gun. Capable of firing 1200 rounds of 20-mm ammunition, the cannon will be used in jet aircraft. Using the revolver gun principle, it involves the use of a multichambered drum indexed by a gas-operated slide mechanism to bring the chambers successively into alignment with the barrel.

Emphasizing the development time involved in such a project, E. M. Wintermoyer, supervisor of small arms research at Armour said, "The task involved in starting with an idea and bringing it to the production stage is enormous." He pointed out that the first burst exceeding 100 rounds was fired after six years of development.

Fast-firing machine gun fires 100 times faster than the Colt revolver. While 12 rounds can be fired in about a minute by reloading the six-shooter, the machine gun fires 1200 rounds of 20-mm high-explosive ammunition

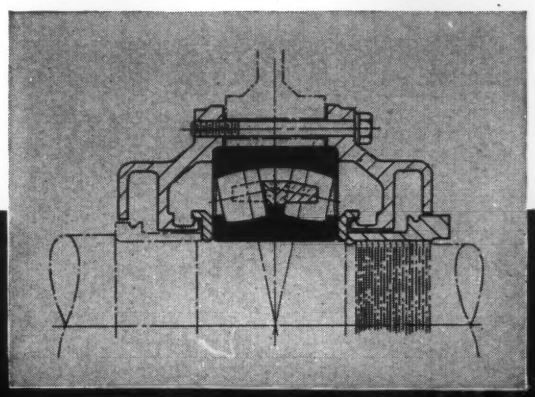


Rolled Splines Made Stronger, Faster

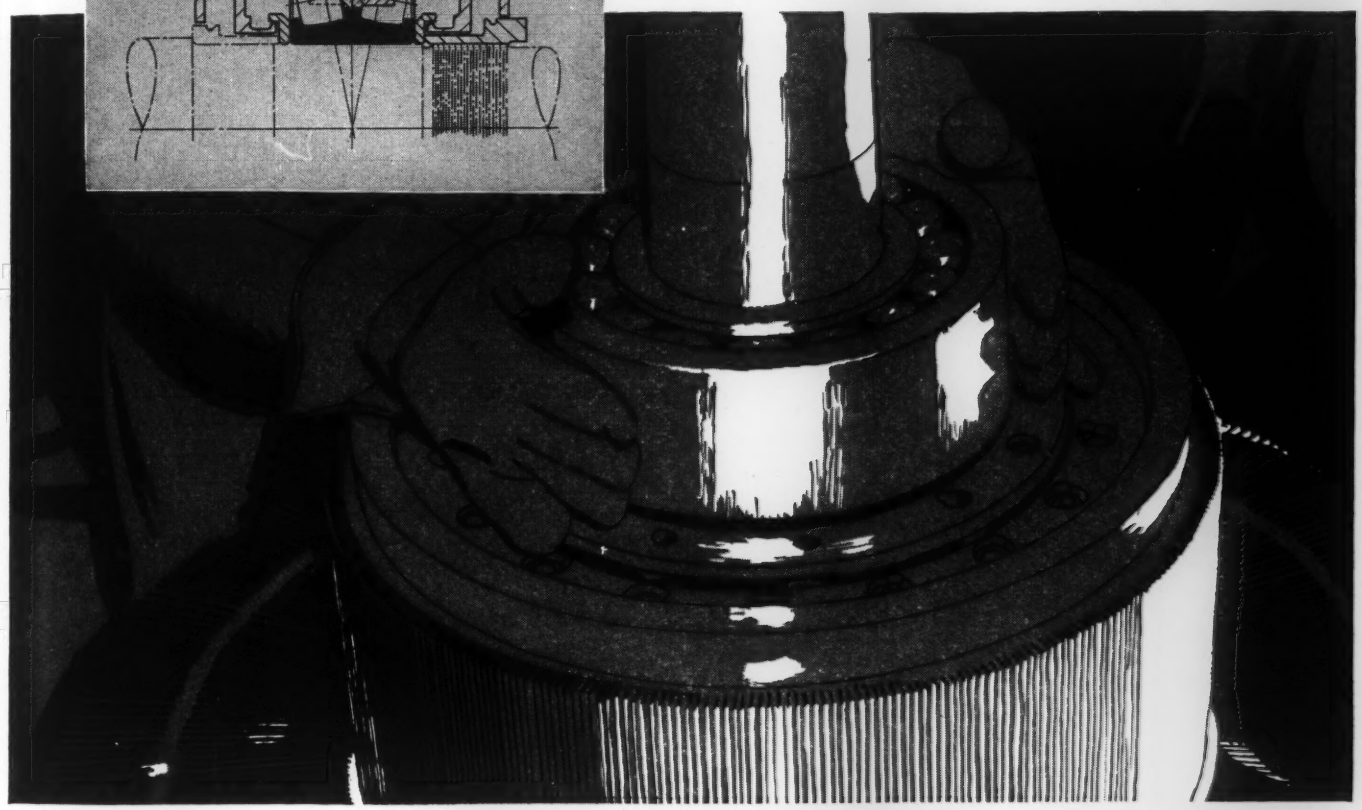
Using a basic new cold-working process for producing splines, oil grooves, serrations, and other similar shapes, a new series of machines called Roto-Flo spline rollers have been announced by the Michigan Tool Co.

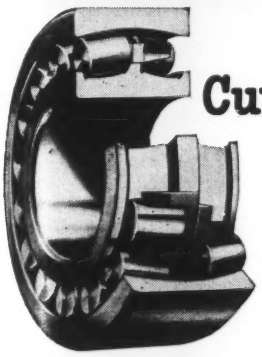
Shafts made to pitch diameter are placed in the forming racks, and the rack teeth press into the metal parts as they roll until proper depth is reached. Resulting

TORRINGTON BEARINGS AT WORK



Precision-ground TORRINGTON Spherical Roller Bearings help cut friction on shaft of a General Electric direct current generator.





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Precision-ground contact surfaces—for even load distribution, maximum bearing life. *Accurate geometrical conformity between races and rollers*—for ultimate load carrying capacity. *Carefully heat-treated races and rollers*—for maximum resistance to shock and wear. *Bronze, machined cage for each path of rollers*—for freedom of operation. *Integral center flange on inner race*—for positive radial stability and positioning for thrust loads. And self-alignment—for smooth service under shock loads at maximum speeds.

TORRINGTON Spherical Roller Bearings are available from stock with either straight or tapered bore for shaft or adapter mountings. Prove to yourself that it pays to buy the finest—specify TORRINGTON.

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TORRINGTON SPHERICAL ROLLER BEARINGS

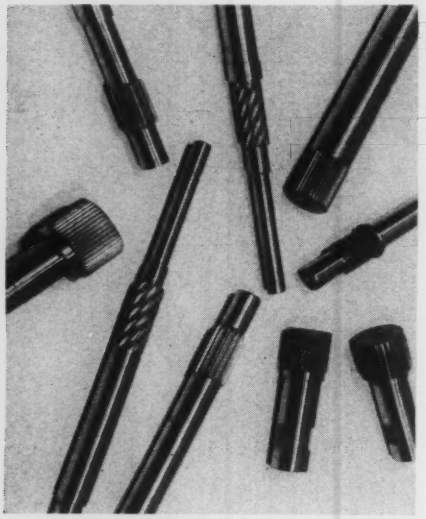
Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers

splines are said to have a high degree of accuracy and excellent surface finish.

Displacing rather than removing the metal also results in a grain structure, with which higher tooth strength can be realized. Early tests have indicated that parts with rolled splines will withstand higher torsion loads than parts with splines hobbed or shaped from the same kind and size of material.

Design flexibility is said to be another advantage of the method. Teeth may be formed up to a protruding shoulder diameter without a recess for tool clearance. Also, finer splines may be used to carry the same load capacity as coarse splines now being used.

Production time is said to be up to 30 times faster for some parts with resulting lower labor costs.



Some of the splines formed by Roto-Flo machines in an average of 3½ seconds forming time. Shafts range from ⅞ to 1⅝-inches outside diameter

PRODUCTION SPORTS CAR is the 1954 Nash-Healey Le Mans hardtop. Major mechanical parts of the car, such as the six-cylinder, overhead-valve engine developing 140 hp, are made in this country. Special chassis with trailing-link front suspension is made by Donald Healey Co. of England. Body is by Pinin Farina

OLD AND NEW in track type tractors. At the left is the second gasoline powered crawler tractor built by the Holt Mfg. Co., one of Caterpillar's parent companies, in 1908. At the right is a modern descendant of the old timer, a D-7 Caterpillar Tractor Co. diesel-powered bulldozer

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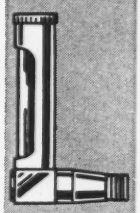

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Yes, only GITS can offer you such a wide range of standard stock sizes. From *just one* source you can get *all* lubrication devices in *any design* for *any purpose.*

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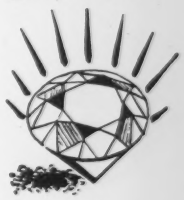

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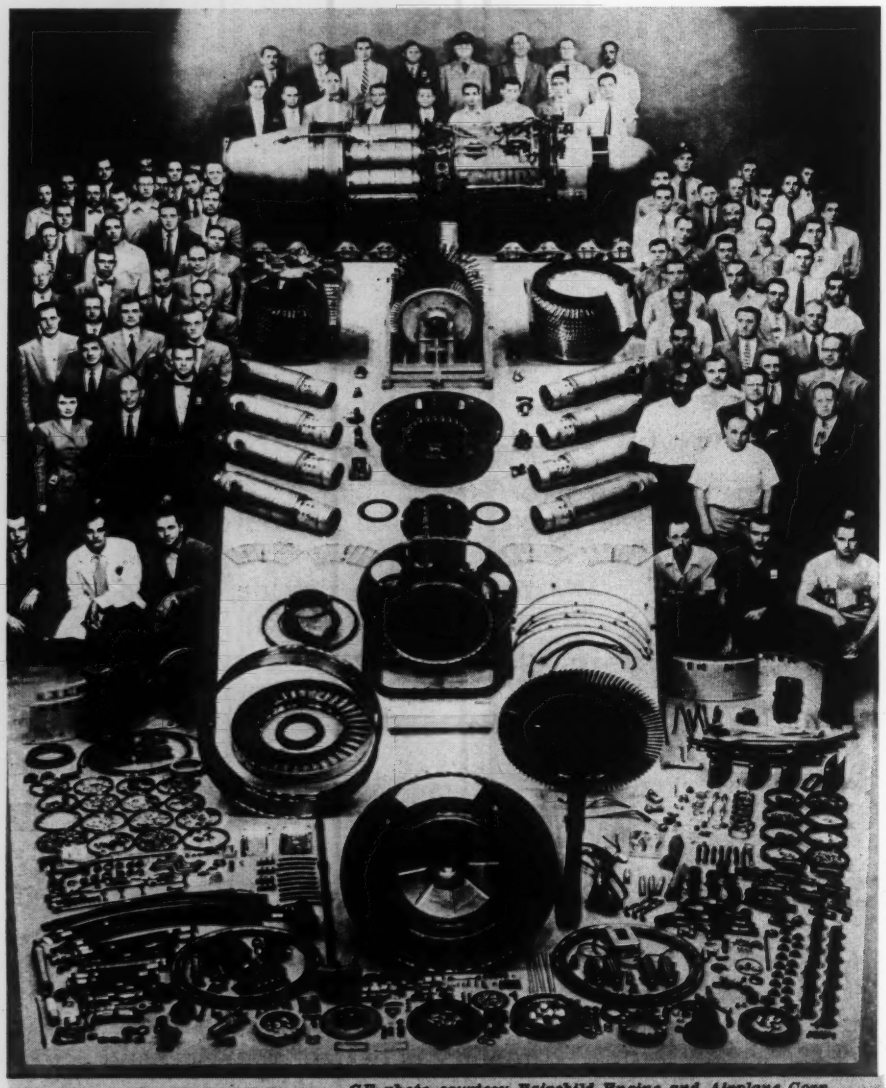


GE photo courtesy Fairchild Engine and Airplane Corp.

MONSTROUS JIG SAW PUZZLE? Not with the skilled help of the 87 people pictured here. These 8,854 parts assemble into a General Electric J-47 jet engine and the group represents the 87 skills required for its assembly

Since all stresses are compressive and not in shear as with cutting tools, longer tool life can be expected.

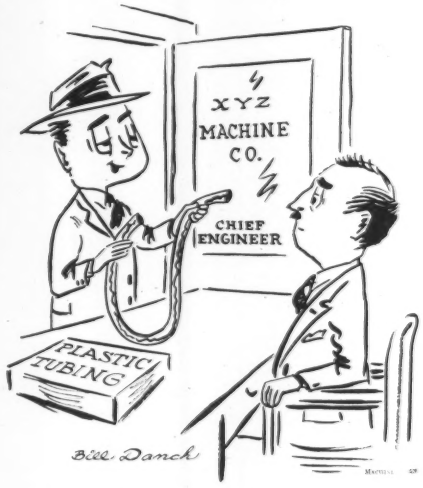
New transformer plant at Rome, Ga., was recently dedicated by General Electric. Costing $25 million, the plant is the first to be constructed for the mass production of power transformers. Rome built transformers are in the medium power range, from 501 to 10,000 kva.

Improved Steel Powder

Development of a new prealloyed steel powder for high strength powder metallurgy applications was recently announced by Vanadium-Alloys Steel Company. According to Dr. George A. Roberts, vice president in charge of technology, the new grade, 4650-A, shows marked improvement over earlier alloy steel powders, and will be marketed immediately by the company.

Improvements in the 4650-A steel powder are said to be reflected in the ability to produce high strength parts by briquetting and sintering without resorting to secondary treatments any more elaborate than simple hardening. Pronounced improvement in the toughness and hardenability of 4650-A powder parts will permit the manufacture of gears and other high strength, high production parts—the field in which powder metallurgy fabrication offers significant cost savings.

Dr. Roberts cited improvements in the characteristics of the new alloy steel powder grade. It is said to have excellent green strength and is readily moldable at low pressures to yield dense, strong compacts. Basically a nickel-molybdenum composition, the grade is also available to users with other carbon contents. Other improvements in the characteristics of 4650-A pointed up by Vanadium are its ease of heat treatment, toughness comparable to alloy steel and its strength.

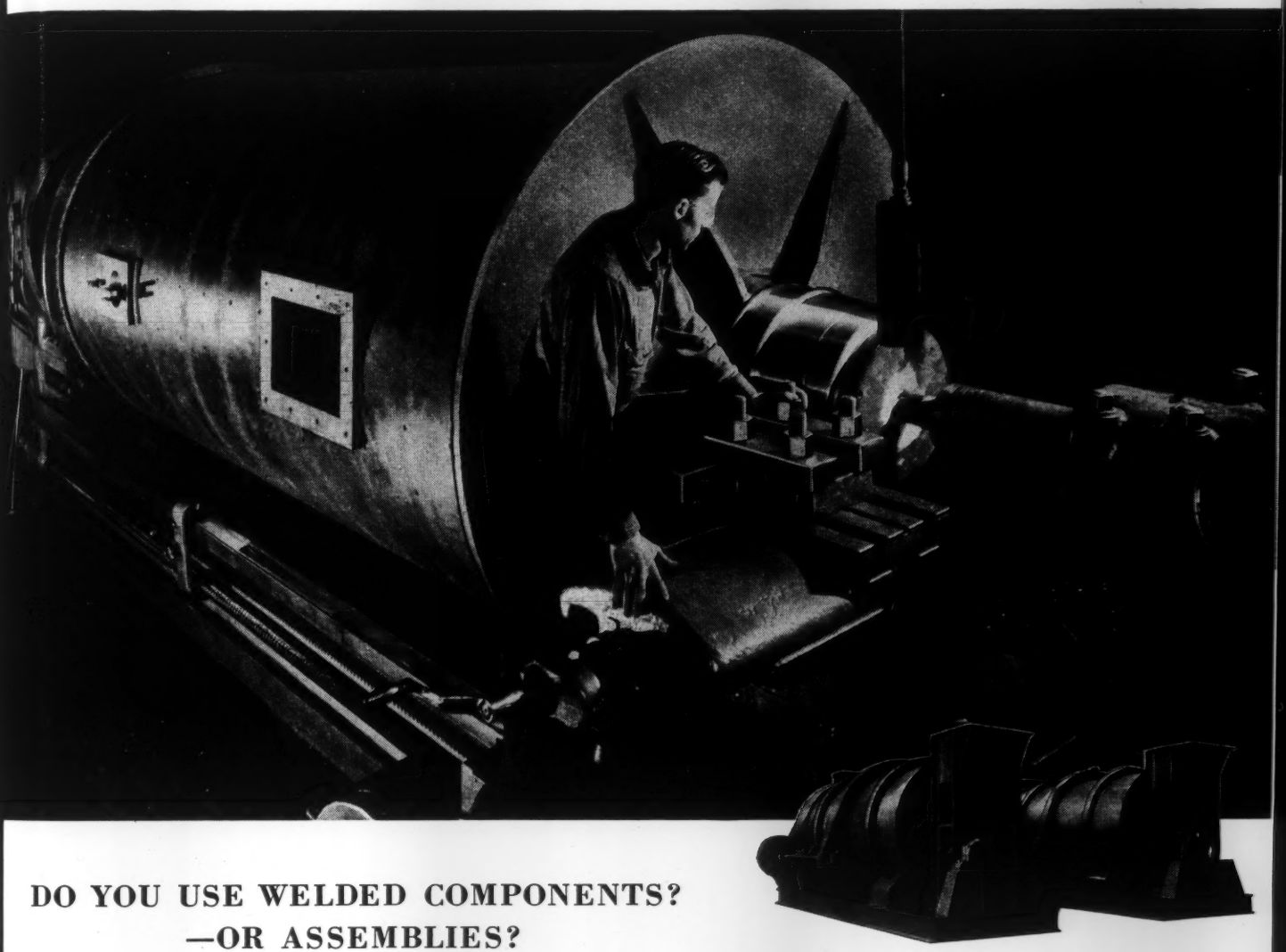


"Most durable substance on the market. Formulated from my wife's cheese rarebit recipe."

Catalytic exhaust mufflers (see MACHINE DESIGN, Page 253, May, 1953), are now being installed on lift trucks and tractors by Clark Equipment Co. Mufflers are also available for field installa-

CONTINENTAL

WELDED STEEL FABRICATION AND ASSEMBLIES



DO YOU USE WELDED COMPONENTS? —OR ASSEMBLIES?

ontinental Weldments production is geared to your needs. ou may need only a sub-assembly like that being finish ma- hined above. You may need a complete fabrication like the pug ill at the right, for which Continental produced and assembled l the parts. In either case, Continental should be your prime ource of supply.

At your service is equipment especially designed and built produce the complex parts for Continental rolling mills. Plus e know-how gained in building such machinery for some of e most exacting buyers in the world.

WRITE

for this new Brochure D on Continental Weldments.

COMPLETE ROLLING MILLS • ROLLS
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East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.
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CONTINENTAL
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Company

tions. Manufactured by Oxy-Catalyst Inc., the muffler converts 95 per cent of the carbon monoxide and hydrocarbons in gasoline engine exhaust gases to carbon dioxide and water vapor.

New Techniques Speed Up Molecular Bonding Process

Special, quick-bond reactivation methods have been developed for use with the Al-Fin bonding process which makes it adaptable to mass production. Working in conjunction with Doehler-Jarvis Corp. to develop the new manufacturing technique, Al-Fin Div. of Fairchild Engine and Airplane Corp. recently announced its use in the production of household electric irons.

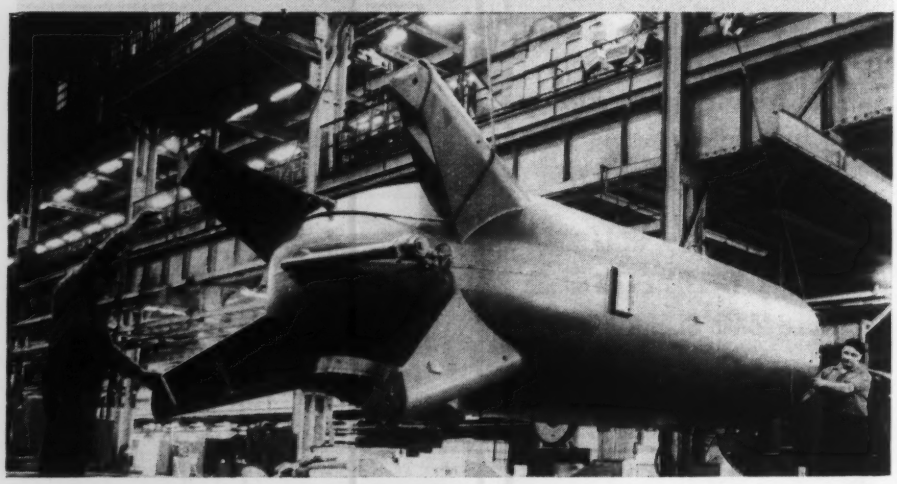
Developed during World War II by Fairchild, the Al-Fin process is a patented casting process for the bonding of aluminum, magnesium and their alloys to steel, cast iron, nickel or titanium. In the present application, stainless steel is bonded to the bottom of a conventional electric iron aluminum soleplate. Prebonding of the stainless steel stampings and storing them at each die-casting machine speeds up the operation.

Pressure die-casting is employed to flatten the 0.01-inch stainless steel sheet after immersion in a molten aluminum bonding bath. Casting metal enters the die cavity at high pressure and conforms the sheet to the contour of the die.

Subsurface porosity in conventional aluminum castings is not usually detected until the piece is finished. Bonding stainless steel to the casting makes subsurface porosity immaterial—one of the advantages of the process—thus reducing rejects and labor costs.

NEW HEAVY TANK was recently shown publicly for the first time. Known as the T-43, the tank has a high-velocity 120 mm gun plus .50 and .30 caliber machine guns. Designed by Army Ordnance and Chrysler Corp. engineers, it is the heaviest and most powerfully armed U. S. tank. Hull and turret are both single-piece castings. An 810-horsepower, 12-cylinder, air-cooled engine provides driving power

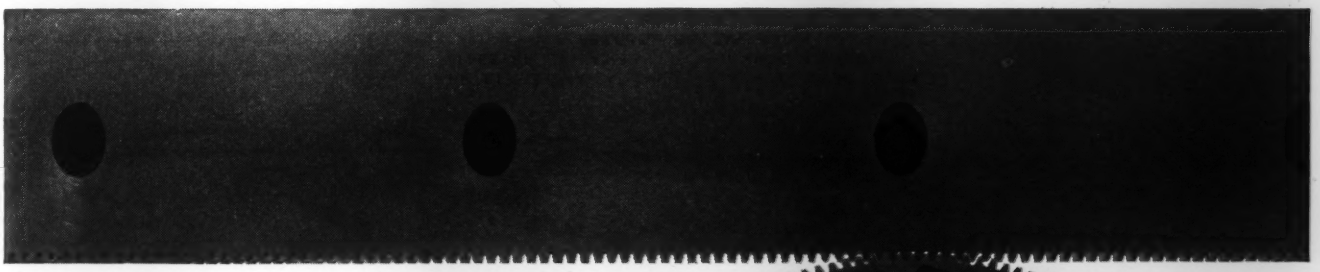
ROCKET SHIP? No, it's a portion of a giant three-pole circuit breaker built for an Ohio atomic energy plant by Westinghouse Electric Corp. Interrupting capacity of 25-million kilovolt-amperes is sufficient to control all the electric power used by a city the size of Pittsburgh



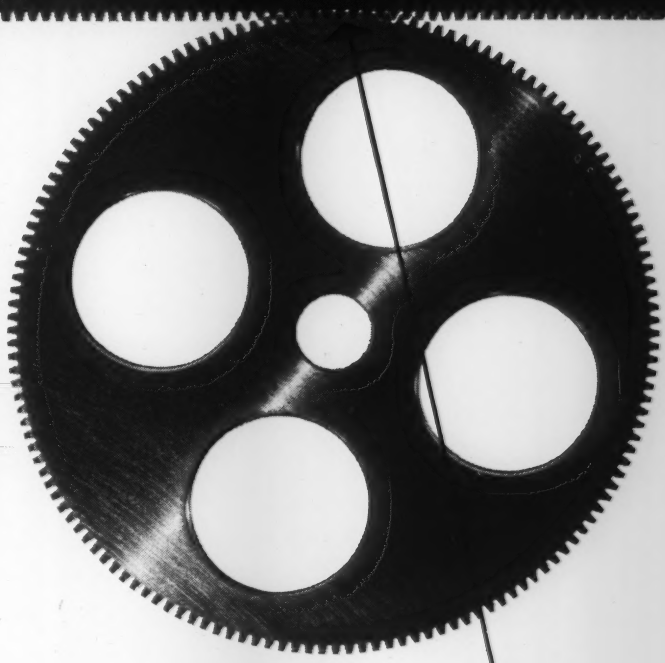
Correction

Clearing Machine Corp. of Chicago has called to our attention that the 300-ton powder metal molding press mentioned in MACHINE DESIGN, May, 1954, Page 206, is not the "largest powder metal press built in this country." Two powder-metal molding presses built by Clearing are rated at 500 tons each.

Atomic energy consulting practice has been opened by James K. Pickard of Washington D. C. Offering his services in the field covering the impact of atomic energy developments on different types of businesses and opportunities for



Why you can *reduce rejection losses* with a Kodak Conju-Gage Gear Checker



Why the composite check

In practice, the final test of gear quality is how the gear works in use. The composite check recommended in American Standard B6.11-1951 shows this conclusively by measuring displacement of the gear when run against a master of known accuracy. And it does it in one quick operation that checks combinations of as many as six types of errors.

Why the Conju-Gage Gear Checker

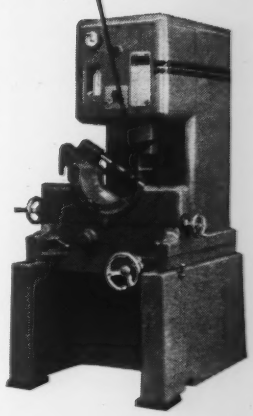
Since displacement represents the sum of both gear error and error in the master, the accuracy of the master used determines the precision of the composite check. The Kodak Conju-Gage Gear Checker uses a master of exceptional accuracy, the Conju-Gage Worm Section. Produced by thread grinding, its accuracy is not limited by the same manufacturing processes which limit accuracy in the gear itself.

To settle for masters of lesser accuracy is to rob yourself of "tenths"—to chance that tolerable error in a gear may coincide with error in the master to cause a needless rejection. Or that intolerable error in a gear may be cancelled by error in the master to pass a gear that will fail in use.

To reject every wrong gear is to guard the quality of your product. To pass every right gear is to reduce such rejection losses to a minimum.

To find out more about how a Kodak Conju-Gage Gear Checker can lower costs while maintaining required precision, send for your copy of the booklet, "Kodak Conju-Gage Gear Testing Principle." Write to

Special Products Sales Division
EASTMAN KODAK COMPANY, Rochester 4, N.Y.



The Kodak Conju-Gage Gear Checker automatically records the composite effects of runout, base pitch error, tooth thickness variations, profile error, lead error, and lateral runout. Illustrated is the Kodak Conju-Gage Gear Checker, Model 8U, for gears up to 8¼" pitch diameter. Smaller models are also available.

CONJU-GAGE INSTRUMENTATION

... a new way to check gear precision in action

To inspect all kinds of complex parts on a bright screen, Kodak also makes two highly versatile contour projectors.

Kodak

business created by atomic energy, Pickard has worked in a number of atomic energy activities continuously since 1944.

Arc Refining Process Promises Beryllium Cost Cut

Refining of beryllium using the Sheer-Korman High-Intensity Arc process is expected to produce better quality metal at about a third of the present cost. Announced by Light Metals Refining Corp. the refining method is believed to be able to produce a nearly pure, nonbrittle and therefore machinable metal.

At the present time, because of the high cost of production and poor quality metal, use of beryllium in industry has been limited, according to the company. Fabricated forms must generally be made by powder-metallurgy techniques rather than machining by conventional means, thus increasing costs. Use of the Sheer-Korman process appears to be a practical method of solving these problems.

World's second lightest metal, beryllium is nonmagnetic and high strength. Machining difficulties have been an obstacle restricting its use as a moderator for nuclear reactors, although significant quantities have been used for other purposes at atomic energy installations. Demand for the metal is expected to increase greatly if the present difficulties are overcome.

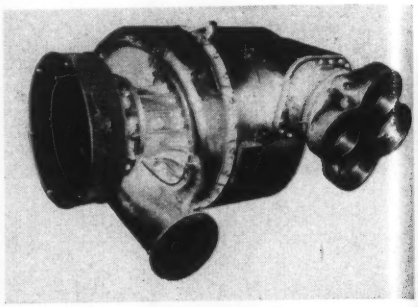
Reduced prices were announced by Du Pont today for its "Teflon" tetrafluoroethylene resin, a plastic with high heat, chemical, and electrical resistance.

Reductions in prices for large containers of "Teflon" ranged from 40 cents a pound for molding powders to $1.00 a pound of resin for dispersions. Fine "Teflon" powder for extrusion of tape and wire coatings was reduced 50 cents a pound for any quantity.

Turbocharger Can Triple Engine Output

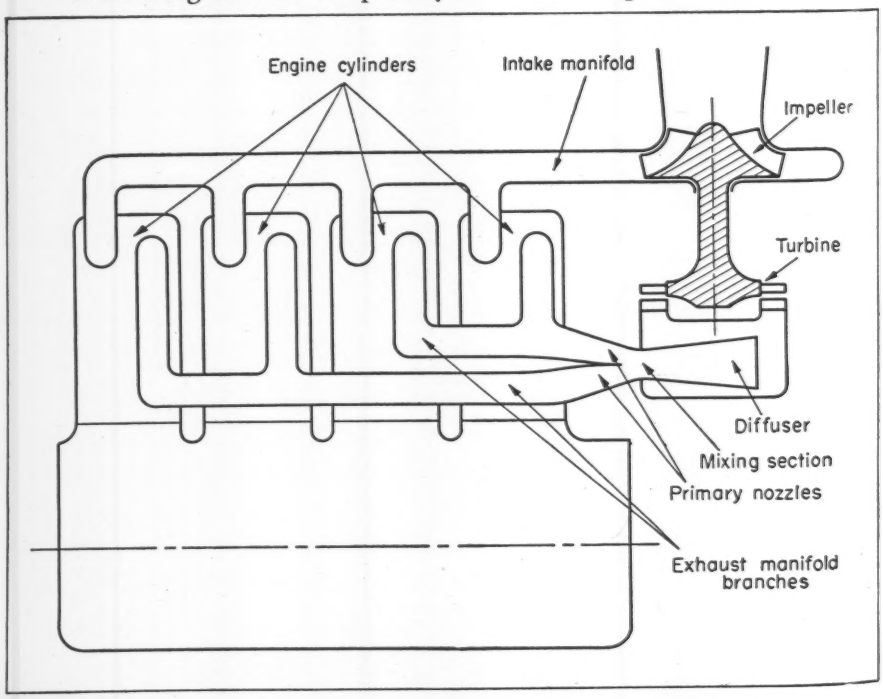
Specific outputs of naturally-aspirated four-cycle Diesel engines have been increased from 2½ to 3 times by a recently developed high-pressure turbosupercharger. Other, perhaps equally important, advantages of very-high-pressure supercharging are reduction of relative cooling losses from 20 per cent of the heat content of the fuel to 8 per cent; reduction of mechanical losses as a percentage of engine output, and possible specific fuel consumption reductions as much as 20 per cent. The new turbocharger is a development of the De Laval Steam Turbine Co.

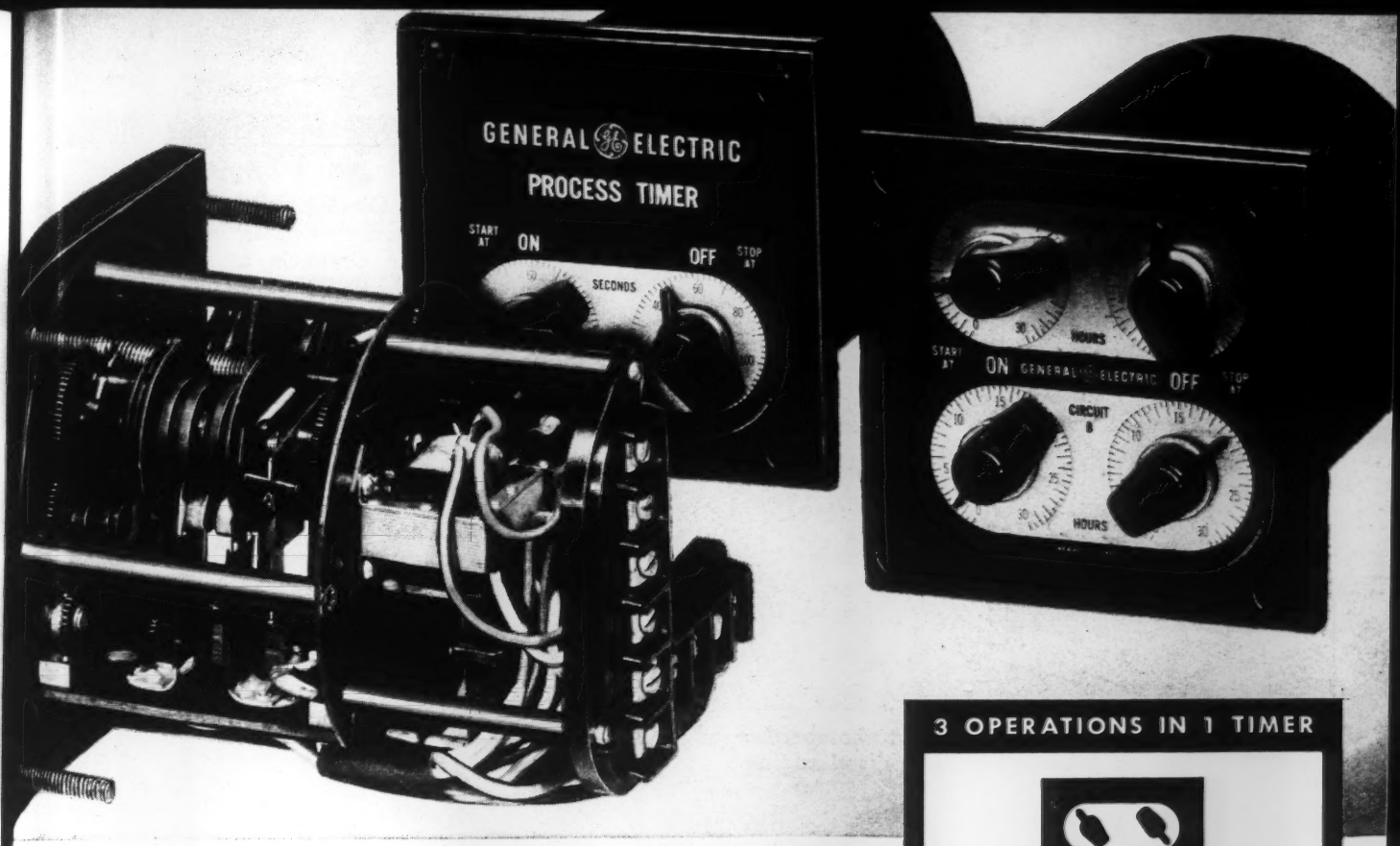
Design of the new turbocharger differs radically from that of conventional turbochargers. A highly efficient new type of mixed-flow compressor and an aerodynamically improved centripetal turbine are used. The unit is also unique with regard to the construction of the rotor, the compressor impeller and turbine wheel being combined in a single rotor structure. Arrangement of the compressor blading on one side of the rotor hub and the turbine blading on the opposite side does away with nonworking surfaces, thereby eliminating parasitic losses such as windage and friction and avoiding compressor and turbine leakage. As the result of elimination of



De Laval turbo supercharger with pulse converter for use with the four branch manifold of an 8-cylinder engine. The pulse converter also serves as an adapter allowing the turbine proper to be used with engines having different sizes and numbers of manifold branches with no modifications to the basic turbine

Pressure waves in one of the two manifold branches are converted into high velocity in the primary nozzle associated with this branch. The high velocity exerts an eductor effect on the other branch. Process than reverses, with the second branch discharging and producing an eductor effect. Fairly uniform high velocity maintained in the mixing section means low static or back pressure. Diffuser converts high mixing-section velocity into pressure increase for driving turbine. Complete system is called "pulse converter"





NEW G-E TIMER

Cuts Process Timing-equipment Costs

The new General Electric TSA-18 process timer, available in single- and double-circuit models, reduces your need for expensive, custom-built timing equipment. Its adaptability enables it to meet, with precise and dependable operation, the majority of your timing-equipment requirements.

THREE TYPES OF CONTROL are available in the TSA-18. At no extra cost this new process timer is capable of being connected for manual start and reset, automatic reset, and automatic reset and repeat operations.

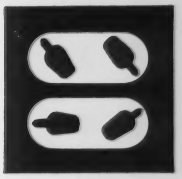
ADJUSTABLE "ON"-"OFF" TIME setting is provided in this new timer. The TSA-18 will begin and end a process at any specified time. Load circuits can be easily adjusted to close or open at any point within this cycle. This feature enables you to reduce the multiple number of timers usually required to perform these timing operations.

HEAVY-DUTY CONSTRUCTION of the TSA-18 reduces maintenance and repair costs and provides long life. Nylon gears, permanently lubricated Telechron* motor, hardened steel parts, and 1/16-inch solid silver-face contacts contribute to the new timer's long life.

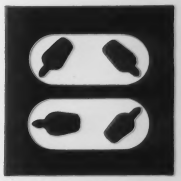
FOR MORE INFORMATION call your nearest General Electric Apparatus Sales Office, or write for Bulletin GEC-1223 to Section 603-179, General Electric Co., Schenectady 5, New York.

*Registered trade-mark, General Electric Co.

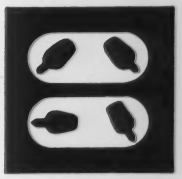
3 OPERATIONS IN 1 TIMER



MANUAL OPERATION
Timer is started and reset manually from an external switch. Two adjustable load circuits independent of each other are available with this type of operation.



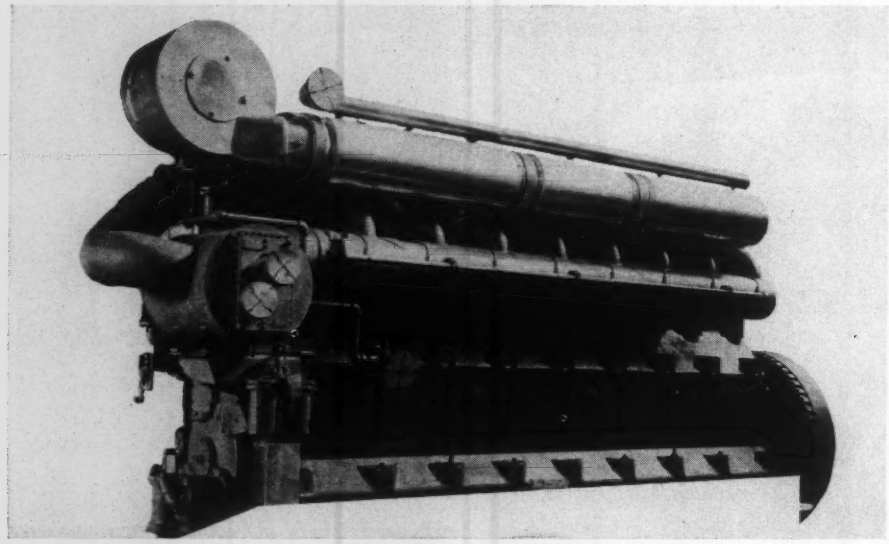
SEMI-AUTOMATIC OPERATION
Timer is started from external switch. Circuit "A" resets time at the end of the adjustable cycle. Circuit "B" opens and closes load circuit within the cycle.



AUTOMATIC OPERATION
Circuit "A" starts and repeats the cycle for continuous operation. Circuit "B" opens and closes load circuit at any point within the cycle.

Progress Is Our Most Important Product

GENERAL ELECTRIC



Installation of De Laval high-pressure turbosupercharger on 1800-hp, 8-cylinder Nordberg diesel engine

these losses, efficiencies of both turbine and compressor are substantially improved, over and above the improvement already achieved by aerodynamic refinement of the blading. This construction eliminates a number of parts such as air and gas seals.

Use of the centripetal turbine has an additional advantage in that the turbine-nozzle guide vanes can be located between two radially - extending walls, which makes it possible to arrange for easy adjustment of the turbine nozzle areas. A simple mechanism can be furnished which permits external adjustment of the nozzle guide vanes during operation of the turbocharger-engine combination. This external adjustment can be used for a variety of purposes, including the achievement of high supercharger rpm under conditions of low engine rpm, thereby obtaining high torque during low-speed operation.

The turbine is of the steady-flow, full-admission type, which makes it most suitable for use in conjunction with the constant-pressure, single-exhaust-manifold engine system, which is now becoming more and more popular. For applications where it is desirable to utilize the energy in the exhaust pulsations (blowdown), De Laval has developed the "pulse converter", which makes the pulsating energy available to the turbine in the form of additional pressure, under conditions of steady flow. This constant-flow system is said to permit higher turbine efficiency by eliminating losses connected with windage of momentarily idle turbine blades and the filling and emptying of stationary passages and rotating blade channels of turbines with conventional blowdown systems.

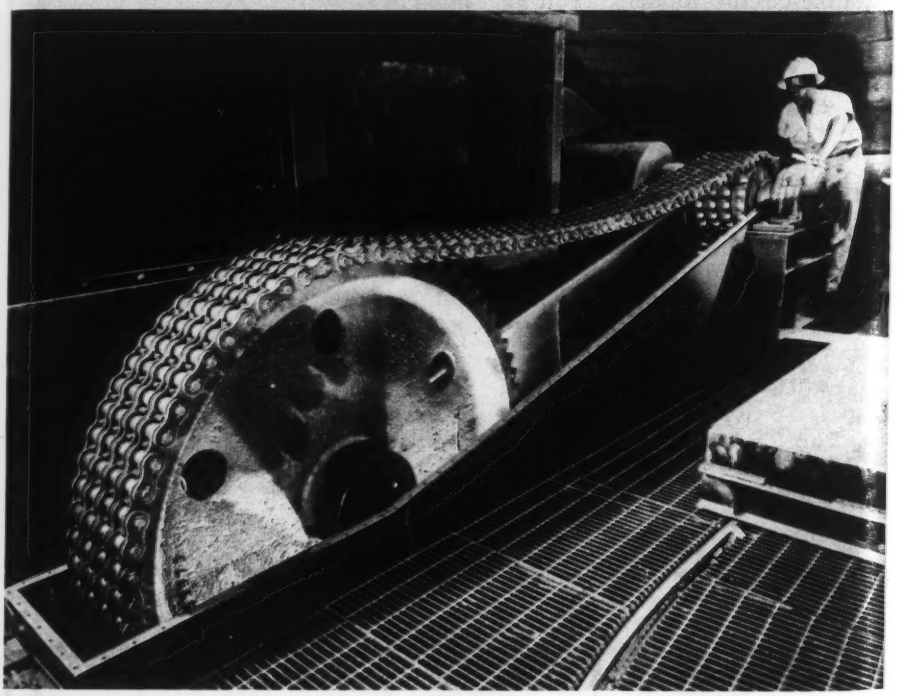
More Reactor Facilities Made Available to Public

Specialized facilities of the Materials Testing Reactor at the National Reactor Testing Station in Idaho have been made available to the public on a limited basis. Recently announced by the Atomic Energy Commission, the facilities are said to make possible greater industrial utilization of benefits from atomic energy developments.

Part of the reactor space available will provide higher neutron intensity than is available to the public at present in other reactors. This higher intensity neutron source is considered a unique research tool.

Because of security considerations, experimental work will be performed by Phillips Petroleum

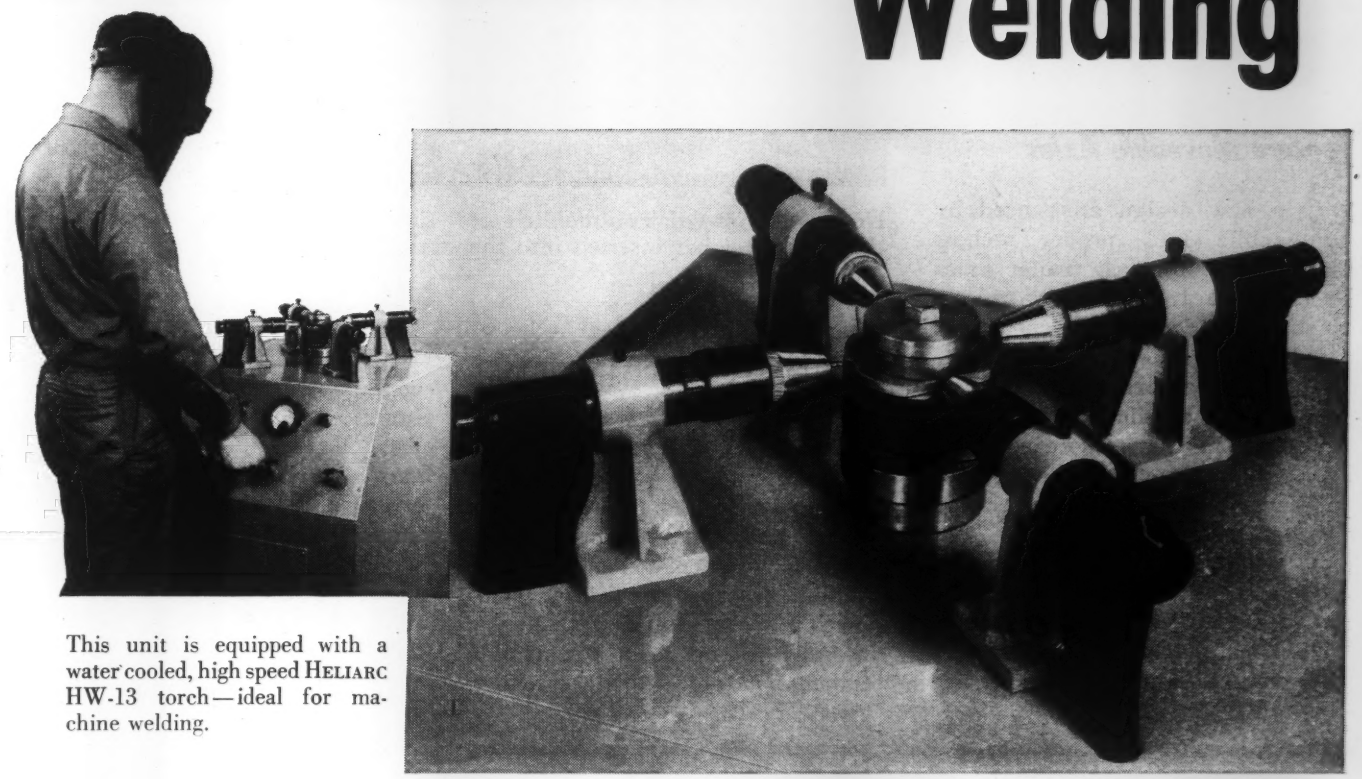
MAMMOTH ROLLER CHAIN DRIVE is one of the largest ever built. Quadruple width 3-inch pitch Link-Belt chain and mating sprockets drive an apron feeder which handles 6000 long tons per hour at an ore-handling facility of the Orinoco Mining Co. in Puerto Ordaz, Venezuela



SAVE 50%

INCREASE PRODUCTION

with HELIARC TRADE-MARK Welding



This unit is equipped with a water cooled, high speed HELIARC HW-13 torch—ideal for machine welding.

Stator packs, thin sheet steel stampings joined together, form the laminated enclosure around the armature in electric motors. These parts have been riveted, bolted, and even welded together in the past... But now using HELIARC welding, they are produced faster and more economically than ever before.

Costs ½ a cent or less to HELIARC weld a stator which previously cost manufacturers one cent to rivet.

Maximum electrical efficiency is obtained with HELIARC welded stators—a quality difficult to obtain from riveted or bolted stators.

Welding speeds up to 60 in. per minute are now possible. HELIARC torches in a mechanized setup weld a complete stator pack in a matter of seconds.

HELIARC, sigma, and UNIONMELT welding processes —brought to industry by LINDE's service engineers, form a top notch fabricating team in operations for small shops or huge production lines. From carbon steel to complex alloys, whatever your welding needs are, your local LINDE representative will be glad to help you determine the most efficient, economical welding process for that work. Call him today for more information.

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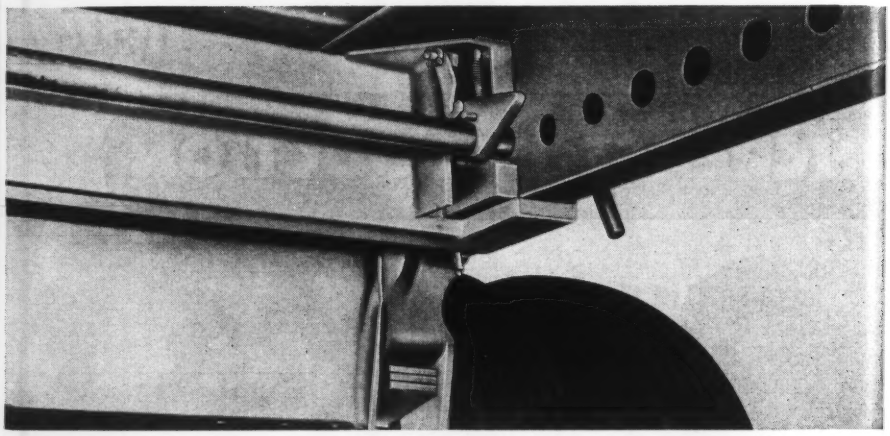
Co., the contractor operating the reactor. Charges, based on all costs involved including overhead, depreciation and operating expense, will be made for public irradiations. These charges, the Commission says, are considered sufficiently low to bring the service within the means of qualified research organizations.

Truck Trailers Feature Moveable Axles

In a new design announced by Trailmobile Inc., proper weight distribution on truck trailer axles is achieved through the use of shiftable tandem axle suspensions. Loading of axles may thus be changed to conform with the various state load limit regulations, thereby resulting in increased payload. In a recent address, James J. Black, vice president in charge of engineering of Trailmobile said that weight distribution in trucks may be achieved in two ways. One is by weight distribution similar to the method of weight and balance used in loading aircraft. The other is to move the rear axles of the trailer to compensate for load position.



Underside view of Trailmobile's new shiftable tandem suspension showing the solid steel bar inserted into the stationary steel beams holding the unit

In either of these ways, Mr. Black remarked, the necessity of reloading due to overloading the axles is eliminated. However, the weight and balance method becomes a problem when different tractors are used since each combination of tractor and trailer is an individual problem. Shiftable tandems therefore, are the logical answer.

Shifting of the axles may be accomplished on the road by blocking the wheels of the suspension, removing the steel rods holding the unit in place, then moving the trailer to place the axle at the desired position. It is shiftable to any position at 3-inch intervals over a 45-inch range.

With a spare unit in the fleet, a further advantage may be realized. The sliding suspension may be replaced with a completely serviced and overhauled unit in about 30 minutes, thus reducing servicing time.

AUTOMATIC AUTOMOBILE SALESMAN provides prospective customers with price information on models of their choice both with and without accessories. Color transparencies display 20 different models. Turning a dial to the number corresponding to a particular model illuminates a description of the car including available optional equipment. Pressing the appropriate button then causes total price to be displayed. Prizes are offered for registering on an automatic register at the right of the machine. Carbon copies of registrations are retained by the machine and serve as sales leads. Recently tested, the device is built by Ohio Displays

Plastic Prototypes Cut Investment Casting Costs

Investment casting prototypes that are less expensive and more flexible than patterns machined out of metal are being used by Precision Metalsmiths of Cleveland. Original "idea" patterns are machined from the plastic and are said to simplify the development of complex castings. Polystyrene patterns may be machined in sections and assembled.

Test casting with the plastic pattern is possible, eliminating the hazard of discovering too late that a pattern won't cast. Further experimentation with various alloys is possible, thus simplifying selection of an alloy.

Easily machined, annealed polystyrene is less expensive than metal. Both factors are said to

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GEAR SHAPING
GEAR GRINDING
GEAR CUTTING
GEAR HOBBING
DRILL PRESS (RADIAL & POWER FED)
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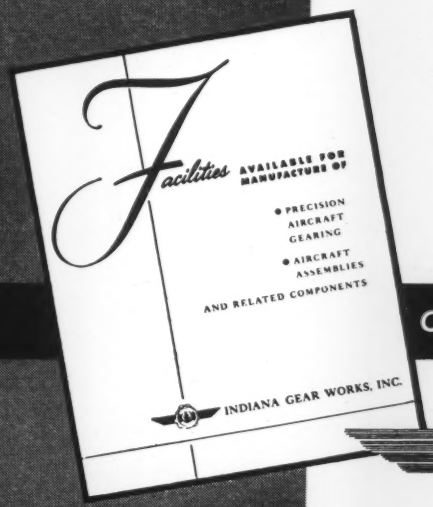
METALLURGY
ROTOBLAST
GUN DRILLING
MILLING
TAPPING
NITAL ETCH
AF APPROVED INSPECTION
ZYGLO
MAGNAFLUX
X-RAY EXAMINING
PARKO LUBRIZE
DICHROMATE
DULITE
COPPERPLATE
CADMIUM PLATE
VAPORBLAST
SPRAY PAINTING & BAKING
ASSEMBLY
DESIGN ENGINEERING



Our complete facilities brochure available on request

INDIANA GEAR

INDIANA GEAR WORKS, INC., INDIANAPOLIS 7, IND.

contribute to greater savings in both time and money in making test castings.

Vinyl Foam Sheeting Now Available in Any Length

Of interest to designers using vinyl foam is an announcement by Kyfoam Inc. of the completion of their new plant for the production of continuous vinyl foam sheeting. Sheeting will be marketed in widths up to 54 inches, thicknesses up to 4½ inches and in any desired length. It will be available in white or any specified color.

Foam vinyl is employed in the automotive and furniture industries as cushioning and molded inserts. It is used for rollers, gaskets, toys, insulation and many miscellaneous products. Capable of being heat-sealed to textiles or plastic sheeting, foam vinyl makes possible a variety of decorative patterns.

Among its desirable characteristics, foam vinyl is said to be tough, nonshrinking and resistant to flame, soap and detergent extractions, chemicals, aging, tearing and abrasion. It does not oxidize, harden or dry out. Further, its properties may be controlled to produce a material that is comparable with soft foam rubber, or with hard, flexible sponge rubber.

Meetings and Expositions

Sept. 5-8—

Pressed Metal Institute. Annual fall meeting to be held at the Manoir Richelieu Hotel, Murray Bay, Quebec. O. B. Werntz, 2860 East 130th St., Cleveland, O., is managing director.

Sept. 7-9—

National Fluid Power Association. Fall meeting to be held at the Hotel Commodore, New York, N. Y. Barrett Rogers, 1618 Orrington Ave., Evanston, Ill., is executive secretary.

Sept. 8-10—

American Society of Mechanical Engineers. Fall meeting to be held at the Schroeder Hotel, Milwaukee, Wis. C. E. Davies, 29 West 39th St., New York 18, N. Y., is secretary.

Sept. 13-24—

Instrument Society of America. International instrument congress & exposition to be held at Convention Hall and Commercial Museum, Philadelphia, Pa. P. V. Jones Jr., 1319 Allegheny Ave., Pittsburgh, Pa., is secretary.

Sept. 21-23—

Society for Experimental Stress Analysis. Fall meeting and exhibit to be held at the Hotel Bellevue-Stratford, Philadelphia, Pa. W. M. Murray, P. O. Xox 168, Cambridge 39, Mass. is secretary.

Sept. 23-26—

Packaging Machinery Manufacturers Institute. Twenty-second annual meeting to be held at Grove Park Inn, Asheville, N. C. Additional information may be obtained from society headquarters, 342 Madison Ave., New York 17, N. Y.

Sept. 27-28—

Steel Founders' Society of America. Fall meeting to be held at The Greenbrier Hotel, White Sulphur Springs, W. Va. Additional information may be obtained from society headquarters, 920 Midland Bldg., Clevelan, O.

Sept. 27-30—

Society of Industrial Packaging & Materials Handling Engineers. Annual exposition to be held at the Coliseum, Chicago, Ill. Additional information may be obtained from society headquarters, 20 West Jackson Blvd., Chicago 4, Ill.

Sept. 28-Oct. 1—

Association of Iron & Steel Engineers. Annual convention and biennial exposition to be held at the Public Auditorium, Cleveland, O. T. J. Ess, 1010 Empire Bldg., Pittsburgh 22, Pa., is managing director.

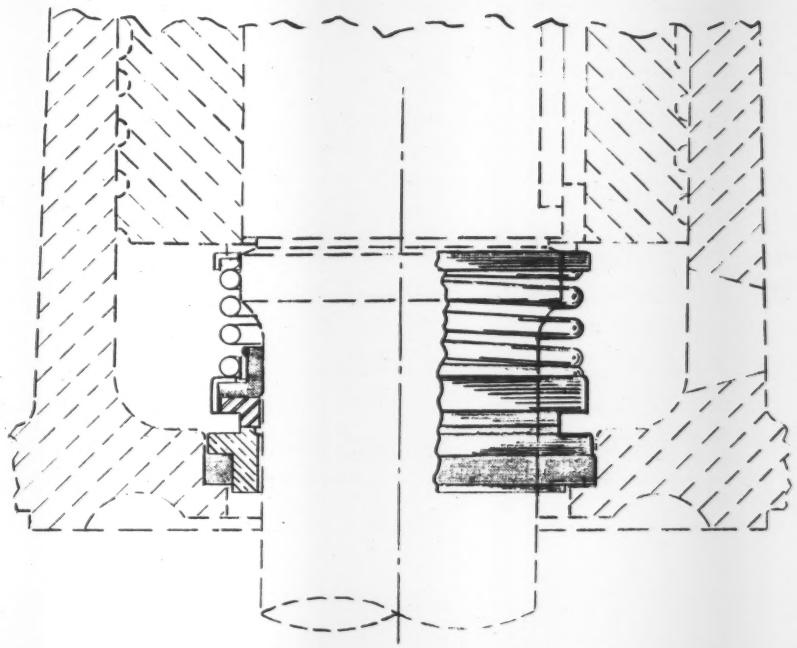
Oct. 4-6—

National Electronics Conference. Tenth annual conference to be held at the Hotel Sherman, Chicago, Ill. Conference under the sponsorship by the American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, Northwestern University, University of Illinois, with participation by the Radio Electronics Television Manufacturers Association, Society of Motion Picture & Television Engineers, Purdue University, and University of Wisconsin. R. E. Hornacek, N.E.C., Publicity Committee, 208 West Washington St., Chicago 6, Ill., is chairman.

Oct. 1-2—

Standards Engineers Society. Annual meeting to be held at Haddon Hall, Atlantic City, N. J. F. M. Oberlander, P. O. Box 281, Camden, N. J., is secretary.

THIS DESIGN STOPS *Gear Drive* TROUBLES BEFORE THEY START



ROTARY SEALS are "tailor-made" to meet *exact* needs!

Whether (as in this case) it's a gear drive, or a pump, windshield wiper or some other equipment, no two designs pose *exactly* the same problems in Shaft Sealing. This important factor in performance and customer satisfaction should be dealt with in the one *best* way. And leading manufacturers in every field have learned that they can get that answer by calling in ROTARY SEAL engineers, preferably at the drawing-board stage of model development.

These skilled engineers are fortified with years of experience in working out many successful solutions to difficult Shaft Sealing problems—often where other methods had proven unsatisfactory. They can adapt the basic ROTARY SEAL principle to meet precise conditions in each case and thus deliver real *Sealing Certainty.* No "off-the-shelf" unit or assembly is likely to provide that specific assurance against trouble before it happens.

ROTARY SEALS

The patented ROTARY SEAL principle we've mentioned is described in our booklet, "Sealing With Certainty" . . . a copy is yours for the asking. And we invite *your* invitation for direct conversations about your specific needs—we've had some of our most satisfying successes in dealing with tough problems which have plagued manufacturers for years.

Shaft-Sealing with Certainty

THE ROTARY SEAL COMPANY

mechanical seals for rotating shafts

2022 NORTH LARRABEE STREET
CHICAGO 14, ILLINOIS, U.S.A.

Helpful Literature

(*Continued from Page 176*)

35. Glass-To-Metal Sealing

Hermaseal Co.—How glass-to-metal seals are made and the facilities for making them preface this 20-page illustrated brochure. Among products made by this process and available from the company are electrodes or terminals, glass seal tubes, multiple electrode sealed headers, octal plugs and grommets. Applications, finishes and design options for each are related.

36. Temperature Indicators

Bryson Oil Co.—"Temperature Testing with Thermocolor and Thermochrom" is an informative and illustrated 8-page booklet which describes a series of temperature indicating pigments and crayons. They change their original color when certain temperatures are reached, acting as color thermometers. Most of them have two, three or four color changes. Temperature range is from 149 to 2255° F.

37. Centrifugal Pumps

De Laval Steam Turbine Co.—Design features and specification data on general service centrifugal pumps are contained in 4-page illustrated catalog 1001B. Pumps, which are available in three sizes from 2½ to 4 in. with capacities to 400 gpm and heads to 230 ft, have life-lubricated bearings and are designed for easy maintenance and service. All parts are standardized and interchangeable.

38. Quick-Disconnect Coupling

Titeflex, Inc.—16-page illustrated catalog "Titeflex Quick-Seal Coupling" contains design information and shows construction features of a quick-disconnect hose coupling for water, oil, steam, gas and chemical lines. Coupling seals tighter as pressures increase and has a full swiveling action to prevent hose kinking.

39. Stainless Steel Wire

Fort Wayne Metals, Inc.—"What Can You Do with Precision Stainless Steel Wire" is title of 4-page illustrated bulletin illustrating some thought-provoking and unusual applications of this material. Wire is available to close tolerances in diameters ranging down to 0.001-in. and finer.

40. Plastic Hose

Resistoflex Corp.—Made from Teflon, Fluoroflex-T plastic hose and hose assemblies are described with test results, sizes and construction features in 4-page illustrated bulletin. Hose withstands highly corrosive fluids at temperatures from —100 to 450° F.

41. Flush Latches & Hinges

Hartwell Aviation Supply Co.—72-page illustrated catalog describes complete line of flush latches and hinges, including data on dimensions, assembly, installation and parts.

42. Industrial Engines

Ford Motor Co.—Six industrial engines with ratings from 45½ to 140 hp are described and their operating curves given in 6-page bulletin TIE 9-7015. Also covered are complete power units and accessories, including Multa Torque converter, power take-off, engine hour meter and other heavy duty equipment. Specifications are given.

43. Magnetic Relays

Essex Wire Corp., R-B-M Div.—Quick reference 4-page bulletin 560A shows various types of open and hermetically sealed alternating and direct current relays. Maximum coil resistance, power requirements, contact forms available and approximate weight and dimensions are provided in tabular form.

44. Impact Extrusion Design

Aluminum Co. of America.—16-page illustrated bulletin AD-376 covers necessary background of designing products for impact extrusion in aluminum. Parts can be one-piece, seamless, semi-hollow or solid and of round, square, rectangular or oblong cross section with ribbed, beaded or fluted side walls. Bases can contain bosses, recesses or lugs and other projections.

45. Thermistor Manual

General Electric Co., Carboloy Dept.—52-page illustrated manual TH-13 is devoted to the subject of thermistors—what they are, how they are applied, and their functions. These include detecting and compensating temperatures and providing time delay or surge control in electrical equipment. Many selection data and useful charts and tables are included in the publication.

46. Brake Motor

Standard Dayton Corp.—Controlled stopping of alternating current motors is possible with the Dinabrake, an alternating current dynamic brake motor. It is mechanically interchangeable with conventional motors. Design features are described and a cut-away view is included in 4-page bulletin 600.

47. Cold Finished Steel

Jones & Laughlin Steel Corp.—Electreat, a J & L heat treated cold finished steel, is subject of text and pictures in 8-page bulletin AD 99. Method of heat treating cold finished steel bars, utilizing electric induction heating and quenching machine is described. Advantages of the method and features of the material are presented.

48. Automatic Transfer Switches

Automatic Switch Co.—"Automatic Transfer Switches" is title of publication No. 502 in which selection material for such switches is considered. Such factors as ratings, single as opposed to double throw, relay protection, quietness of operation, control, operating speed and other factors are considered. Wiring diagrams and photographs are included.

49. Drawing Hold-Down Device

Grand Valley Machine & Tool Co.—Designed for holding-down stock during drawing or forming press operations, Die-Draulic hydraulically operated gripper is covered in 4-page illustrated catalog. Operating principle and features are discussed. Unit is automatic in operation and has simple provision for regulation of hold-down pressure.

50. Centrifugal Castings

Wisconsin Centrifugal Foundry, Inc.—8-page illustrated catalog covers a nonferrous metals centrifugal casting service. Facilities are available for casting shapes ranging from very small and intricate designs to sizes up to 48-in. OD, 40-in. long and up to 3000 lb in weight. All phases of the design and production operation are covered.

51. Bearing Selection Guide

Thomson Industries, Inc., Bearing Dept.—Bearing application evaluation chart lists 17 basic performance and application elements to be considered in bearing selection. Various types of bearings can be listed with regard to application, the one with the highest number of favorable "checks" being indicated as the one to be used.

52. Rubber Sealing Ring

Minnesota Rubber & Gasket Co.—A four-lipped rubber seal that resists spiral twist, the Quad Ring, is described in available literature. Detailed information is given on applications, engineering features and characteristics. Cross-sections illustrate behaviour under various pressures. Sizes, dash numbers and tolerance variables are listed.

53. Worm Gear Jacks

Duff-Norton Mfg. Co.—Worm gear jacks, described in illustrated 8-page bulletin AD-34, are used as components of machines and equipment for control of linear motion, applying pressure and resisting impact. Two or more can be connected to raise or lower in unison. Units are offered for capacities from 5 to 35 tons, 3 to 25-in. raises and 8:1 to 96:1 worm gear ratios.

54. Magnesium Plate & Sheet

Brooks & Perkins Inc.—Use of magnesium plate and sheet to reduce weight is covered in 4-page data bulletin. Comparative properties are given in chart form for mechanical properties and weights of typical structural metals. Range of company sheet and plate magnesium products is also shown in table form.

55. Packaging Materials

Cincinnati Industries, Inc.—Design engineers portfolio of Cindus packaging and insulating materials contains samples of various types and grades of X-Crepe, Elastikraft and Corrucrepe. Information on application of these products is also given.

56. Silicone Rubber Selection

Dow Corning Corp.—"Silastic Facts 9-334" is title of a 4-page data sheet containing material useful for selection of correct grade of Silastic silicone rubber for any given application. Properties of the various products are covered in detail and fabrication and application methods are shown.

57. Bearings & Bushings

O & S Bearing Co.—Oscillating, rotating or sliding movements where lubrication is difficult or impossible can make use of NeverOil nonmetallic bearings and bushings, described in 4-page bulletin 251. Application and design information is included.

58. Bimetal Disk Thermostats

Stevens Mfg. Co.—Type A bimetal disk thermostats including semi-and hermetically-enclosed types are covered in 2-page illustrated data sheet L-9070. Operating temperatures range from —40 to 400° F on semienclosed models. Sealed units can be used in explosive atmospheres or at high altitudes. Specifications and other data are provided.

59. Heavy-Duty Limit Switch

R. B. Denison Mfg. Co. — Heavy-duty Loxswitch limit switch which features trigger-type mechanism is described in 4-page illustrated catalog "The Inside Story." Made to JIC standards, switch is available with various types of operating lever arrangements. It is of single-pole double-throw double-break design.

60. Magnetic pump

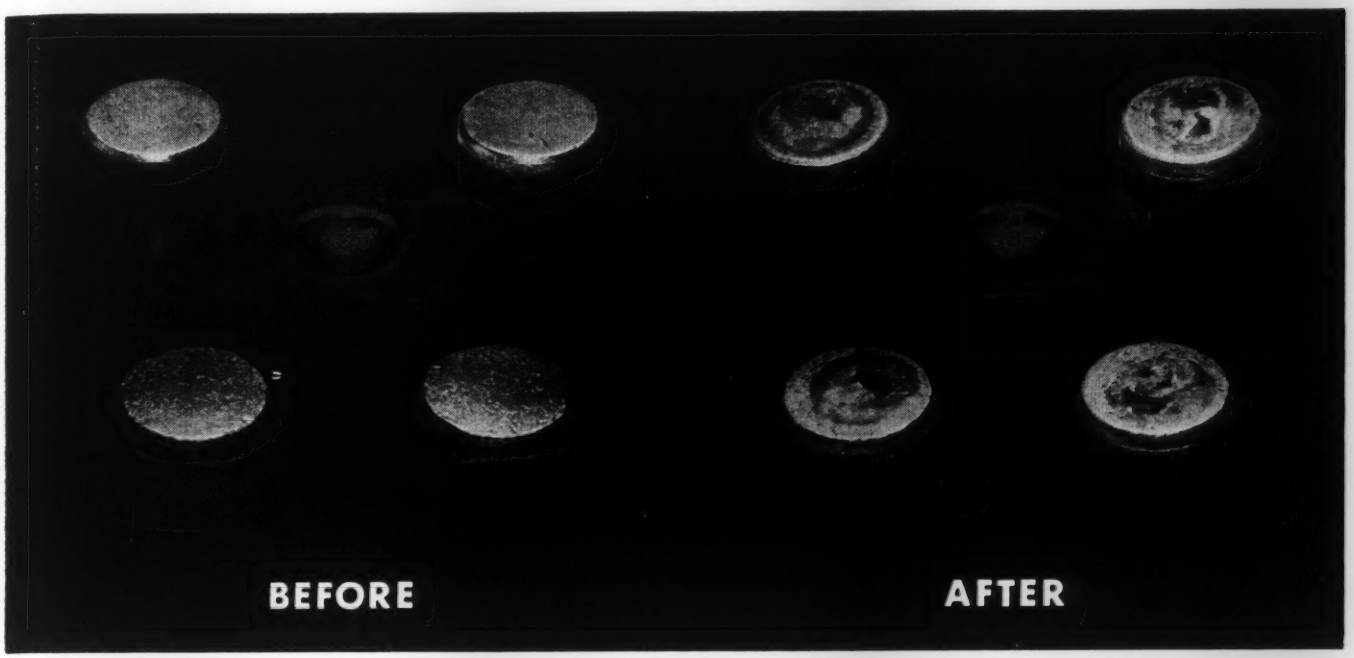
Fostoria Pressed Steel Corp.—Magnetic force is used to rotate the impeller of the Dynapump. It features stainless steel construction, motor and pump in one sealed unit and built-in low voltage and overload protection. Units in line deliver 5, 10, 15, 20 and 25 gpm. They are described and illustrated in 4-page bulletin C 1053.

61. Screw Thread Handbook

Greenfield Tap & Die Corp.—54-page screw thread manual gives a wealth of data on Unified and American screw threading procedures and standards. Tolerances, thread measurement, limits, and suggested taps and tap drills are covered in detail for complete range of thread sizes. All information is given in quick-reference tabular form. Data are also provided on tapping speeds and lubricants and drilling speeds and lubrication, with reference to type of machine operation, material and feed.

62. Steel Tubing.

Higbie Mfg. Co., Avon Tube Div.—12-page illustrated bulletin provides design data and specifications on a line of Fusionweld steel tubing. Product characteristics are evaluated with respect to use in adverse operating conditions. Various grades are available in a full range of sizes from $\frac{1}{16}$ to $\frac{5}{8}$-in. OD. Tubing is available "as welded", annealed and in hard drawn forms, and is characterized by good ductility and strength. Uses are shown.



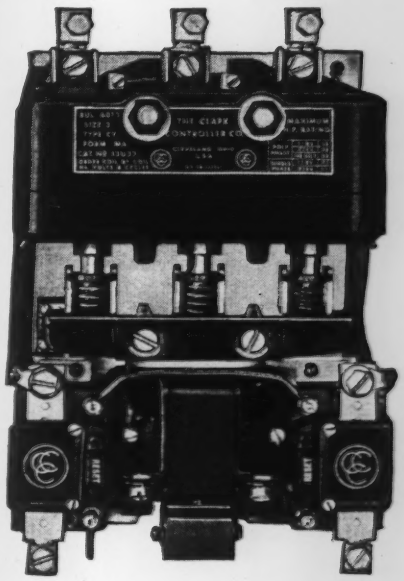
PROOF OF LOW MAINTENANCE ON CLARK TYPE "CY" STARTERS

These unretouched photos show contact tips from a CLARK Bulletin 7707 contactor—the contactor used in the standard Bulletin 6013 size 2 AC Motor Starter — as they looked before and after a year of hard use.

The contactor is in service at Cleveland Hone and Manufacturing Company, on a special transformer and rectifier circuit used in processing automotive parts. The tips shown right above were removed from the contactor after 12 months of steady service, often operating as frequently as 5000 times per hour.

Note that slight discoloration and minute pitting are the only evidence of wear. They require no cleaning, dressing or filing, and are in condition to give many more years of dependable service.

The secret of long contact life in the CLARK Type "CY" Starter is its exclusive arc-quenching principle, using strong multi-turn magnetic blowouts and double-break contacts. Forced rotation causes the arc to move continually on the contact surfaces, distributing the heat and preventing pitting or "build-up" at any one point. Result: extremely effective arc interruption, and greatly reduced wear on tips.



CLARK Type "CY" Starters include many more features for dependable service and reduced maintenance. Let us tell you the complete story.

Write for descriptive literature.

The CLARK CONTROLLER *Company*

Engineered Electrical Control

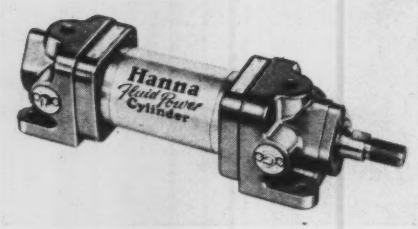
1146 East 152nd Street • • Cleveland 10, Ohio

NEW PARTS AND MATERIALS

For additional information on these new developments, see Page 175

Air, Hydraulic Cylinders

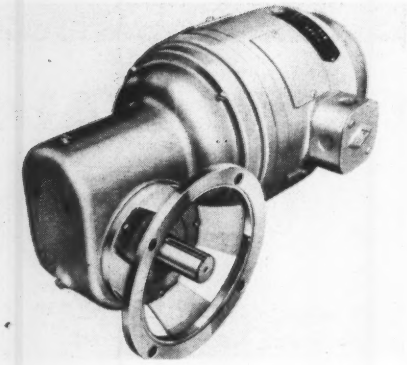
Large capacity to size ratio, easily adjustable cushions, minimum friction consistent with sealing and corrosion resistance are among characteristics of series 750 fluid power cylinders for air and hydraulic service up to 750 psi. Cushions have positive action over full stroke and allow immediate full flow on return stroke. Self-adjusting packings and bronze glands are fitted. Ground and polished rods are of alloy steel, and high alloy iron heads are corrosion-resistance treated inside and out. Piston is also treated for corrosion-resistance and is of one-piece construction, grooved for synthetic packings. Cylinders meet JIC standards. Made by **Hanna Engineering Works**, 1751 Elston Ave., Chicago 22, Ill.



For more data circle MD-63, Page 175

Fluid-Coupled Speed Reducer

Fluid-cushioned starting is incorporated in this worm type speed reducer, which is adaptable to powering loads that require



smooth, gradual acceleration. Installation is facilitated by compact size and provision for 16 different mounting positions. Units are available in ⅓ and ½-hp ratings in 66W frame size; ¾ and 1 hp in 204W frame; 1½ hp in 225W frame; and 2 hp in 254W frame. Output speeds from 24 rpm through 140 rpm are offered. Units can be ring or foot mounted. Made by **Reuland Electric Co.**, 3001 W. Mission Rd., Alhambra, Calif.

For more data circle MD-64, Page 175

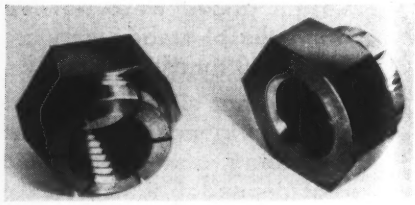
Coated O-Rings

Kel-F coated silicone rubber O-rings are resistant to aromatic, chlorinated or other solvents that normally attack silicone rubber. Coating does not affect low temperature properties of the silicone rubber, and the useful temperature range of the O-rings is approximately −120 to 390 F. Made by **Bacon Industries Inc.**, 192 Pleasant St., Watertown, Mass.

For more data circle MD-65, Page 175

Self-Locking Nuts

Added to line of Flexloc self-locking locknuts are series 32FE engine nuts for use where temperatures do not exceed 550 F. Nut has integral metal washer face on seating side. This face, a 1/32-in. thick circular collar, can be machined to closer tolerances than full seating face of standard Flexloc nut. Squareness with pitch diameter is held to within 0.005-in. on sizes through 7/16-in. and to within 0.006-in. on ½-in. diameter nuts. Series is offered



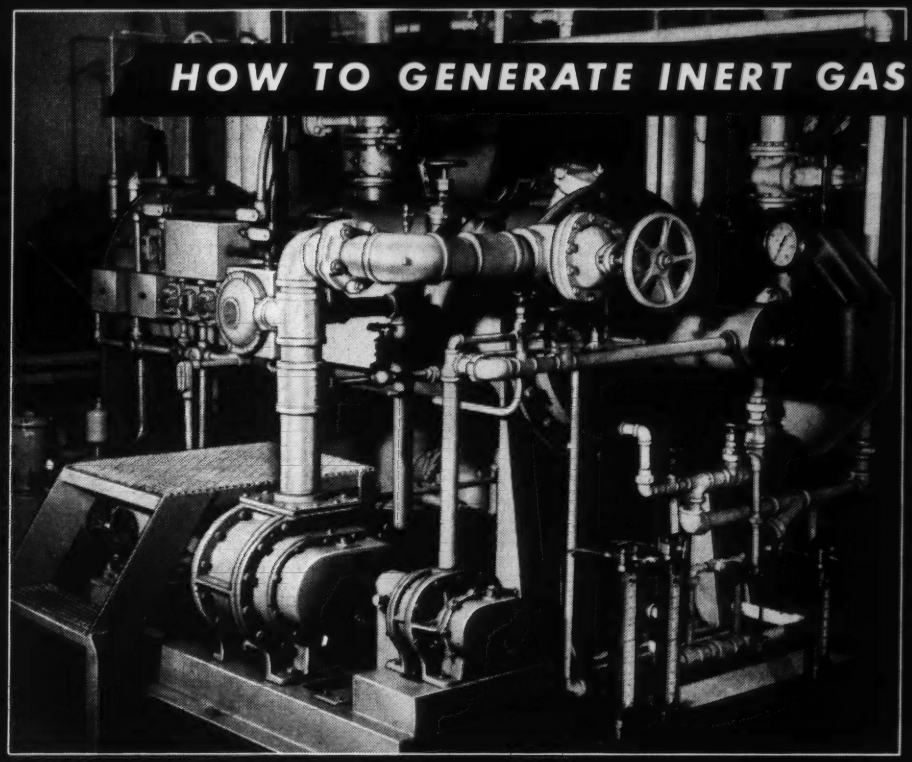
in sizes from 0.190 to 0.500-in. diameter. Nuts are AMS 5024C alloy steel and are cadmium plated for corrosion resistance. They are stop nuts as well as locknuts. Made by **Standard Pressed Steel Co.**, Stewart Ave., Jenkintown, Pa.

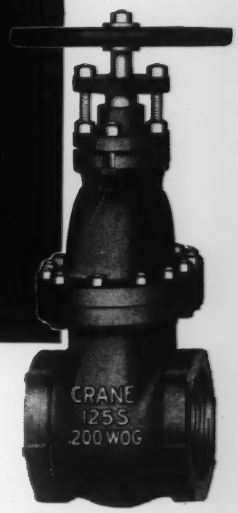
For more data circle MD-66, Page 175

Flexible Shaft Coupling

Measuring ½-in. in diameter and 11/16-in. long, Tinymite flexible shaft coupling permits 5 deg angular or 1/16-in. offset misalignment. It fits ¼-in. diameter shafts. Coupling has nylon insulator and nickel

HOW TO GENERATE INERT GAS IN VOLUME





Crane 125-Pound Iron Body Wedge Gate Valve . . . recommended for all services where greater strength and long valve life are of prime importance. Body and bonnet are oval-shaped with extra metal where it's needed most. Flanged patterns have tie-ribs between body and bonnet. Long guides assure proper seating of the solid web-type disc. An exceptionally deep stuffing box filled with high-grade packing provides a tight stem seal. Selection includes all-iron or brass-trimmed valves in non-rising stem or OS&Y patterns. Sizes up to 48-inch. You can also specify OS&Y valves with brass seats and steel stem.

another successful product design with piping equipment by CRANE

Inert gas can be generated at the rate of 18,000 c.f.h. in this variable capacity unit by *Roots-Connersville Blower* of Connersville, Indiana. This division of Dresser Industries Inc. is also recognized for rotary positive blowers for pressure and suction, gas exhausters and boosters, cycloidal pumps for handling viscous liquids, gas and liquid meters, centrifugal blowers and exhausters, and also vacuum pumps.

Designing dependability into a wide range of equipment like this is a big job made easier when you specify Crane quality for the valves and fittings. The broad Crane line eliminates the need for selecting dubious alternates. And the complete Crane Catalog gives you full data for every piping item . . . sizes and dimensions, temperature and pressure ratings, plus details on materials and construction. Big reasons all, why Crane is the piping choice of so many product designers.

YOU'LL FIND IT HERE ...IN YOUR CRANE CATALOG

THE BETTER QUALITY...BIGGER VALUE LINE...IN BRASS, STEEL, IRON

CRANE VALVES

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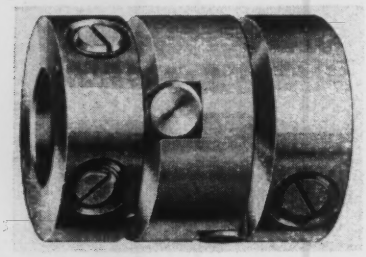
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

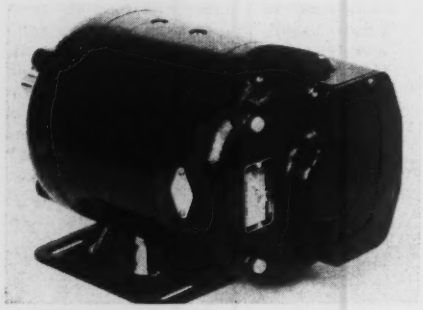


plated brass hubs. Applications include manual controls, plug-in units, subminiaturization and low power transmission. Made by **Renbrandt Inc.**, 98 Kirkland St., Cambridge 38, Mass.

For more data circle MD-67, Page 175

Fractional-Horsepower Motors

Suitable for general purpose, constant-speed applications, redesigned line of 60 and 70-frame size compound-wound dc motors incorporates an enlarged terminal box and improved brush mounting. Larger terminal box, which has six-lead capacity to facilitate installation, has not altered motor's basic dimensions. Rubber-mounted bearings have increased life and give quieter operation with less vibration, and the new brush assembly provides greater creepage distance, higher dielectric

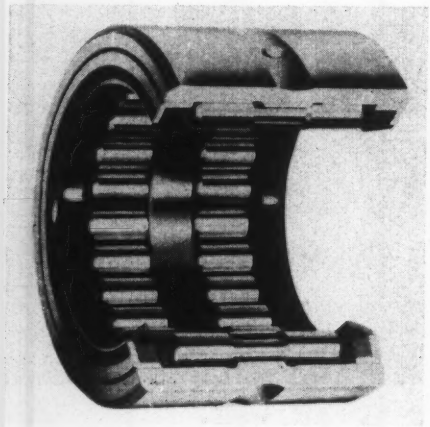


strength and improved aging characteristics. Motors also have die-cast aluminum fans. Operating at speeds of 1725, 1140 or 860 rpm, the motors are available in ratings of ⅓, ½ and ¾-hp, and 115 or 230 v. They may be operated at variable speeds by derating, or reconnected for use as shunt motors, self or separately excited. Made by Specialty Component Motor Dept., **General Electric Co.**, Schenectady 5, N. Y.

For more data circle MD-68, Page 175

Sealed Bearing

Available with either single or double seal, Guiderol bearing prevents contamination by dirt and retains lubricant. Seal, which is applied to stock bearings, consists of a metal stamping with a rubber

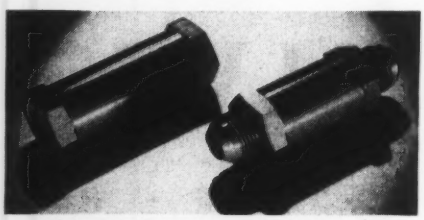


"rind" bonded to one side. It is located in the outer race bore by means of a heavy press fit. The rubber is lipped to provide an interference fit with the shaft or inner race OD on which it is to operate. Made by **McGill Mfg. Co. Inc.**, 909 Lafayette St., Valparaiso, Ind.

For more data circle MD-69, Page 175

Hydraulic Check Valves

Two series of high-pressure, free-flow valves can be used on all hydraulic systems operating at pressures to 3000 psi. Mountable in any position, they are designed for fast opening and delivery of full line capacity with minimum

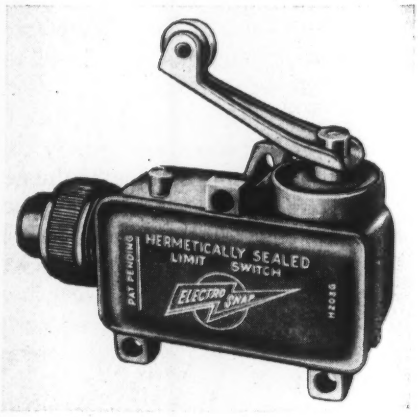


pressure drop. Valves withstand the mechanical shock of continuous action of the poppet against the valve seat. CIS series valves, comprising five models, are of cone type design with JIC flared tube connections which mate with Triple-lok sleeve and nuts. Cracking pressure is 5 or 65; rated flow ranges from 3 to 28 gpm; tube OD, from ⅜ to 1 in.; overall length, from 2⅞ to 5⅛ in.; weight, from 0.313 to 1.612 lb. The five models of the CIT series are in-line cone type with internal IP thread connections. Cracking pressure is 5 or 65; rated flow is from 3 to 28 gpm; tube OD, from ¼ to 1 in.; length, from 3 to 5⅛ in.; weight, from 0.206 to 1.500 lb. Made by Industrial Hydraulics Div., **Parker Appliance Co.**, 17325 Euclid Ave., Cleveland 12, O.

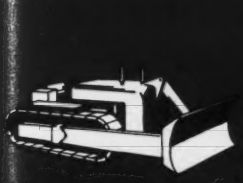
For more data circle MD-70, Page 175

Sealed Limit Switch

Hermetically sealed against oil, dirt and other foreign materials, switch is also unaffected by extreme temperature variations and moisture. Unit consists of a standard basic switch protected



by a sealed housing with integrally mounted actuator. Electrical leads are imbedded in a glass-to-metal header providing a positive, leak-proof seal to the connector. Teflon and silicone diaphragm is bonded in place by a mechanical seal retainer. All vital components are sealed in an inert gas. Electrical rating is 10 amp at 125 or 250 v dc; 10 amp at 28 v dc in-



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There's only one *best* hydraulic pump for any job—*and it's PESCO!* On thousands of hydraulic applications with capacities up to 60 gpm and pressures to 3000 psi, PESCO Pressure Loaded PUMPS have proved to be the *one best* answer to continuous peak performance.

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PRODUCING THE BEST IN HYDRAULIC EQUIPMENT AND ELECTRIC MOTORS

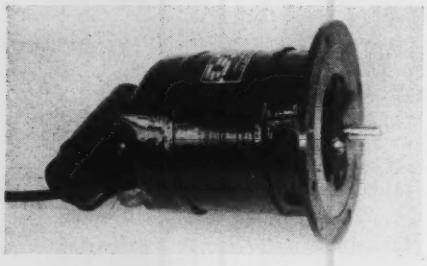
BORG-WARNER CORPORATION
24700 NORTH MILES ROAD • BEDFORD, OHIO

ductive. A variety of actuators is available to fit specific applications, including roller actuator illustrated. Made by **Electro-Snap Switch & Mfg. Co.**, 4218-30 W. Lake St., Chicago 24, Ill.

For more data circle MD-71, Page 175

Synchronous Motor

Motor designated RBH-5425 is rated 1/12-hp, 115 v 60 cycles, 1800 rpm. It has ball-bearing construction and is flange-mounted, designed for vertical operation with shaft up, but may be mounted

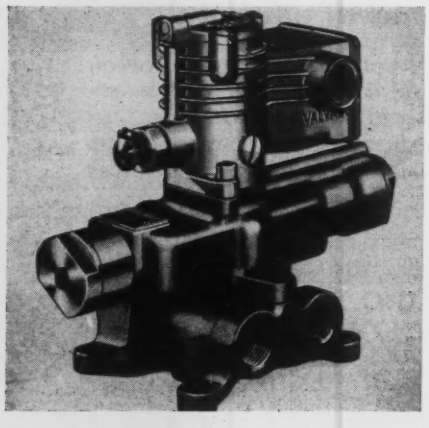


in any position. Measuring approximately 5½ in. in diameter, motor is of the reluctance type, with squirrel cage rotor having no brushes or slip rings. Made by Holtzer-Cabot Motor Div., **National Pneumatic Co. Inc.**, 125 Amory St., Boston 19, Mass.

For more data circle MD-72, Page 175

Air Control Valve

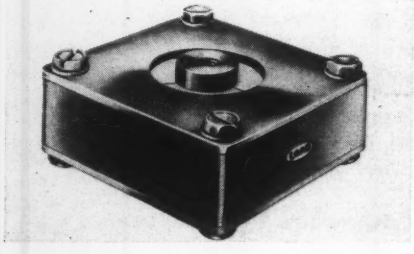
Designed for use in the 35 to 200-psi range for air and low-pressure hydraulics, Speed King solenoid pilot-operated control valve is available in any voltage and cycle requirements. Totally enclosed valve meets JIC standards and has electrical junction box cast integral with pilot control housing. Pilot can be mounted in two positions over the base and is universal to all assemblies. All parts are corrosion resistant, base being cast bronze and the pilot valve a zinc-base alloy casting. Two, three, four and four-way five-port (two pressure) models with pipe sizes from ¼ through 1 in. are offered. Foot or manifold mounting is optional in all models except the two-pressure type. Made by **Valvair Corp.**, 953 Beardsley Ave., Akron 11, O.



For more data circle MD-73, Page 175

Vibration Damper

Developed to provide the additional damping required in many vibration control systems, this unit permits varying the amount of damping to fit the particular characteristics of a suspension system. Unit reduces the amplitude at resonance, resulting in lower forces being transmitted to the

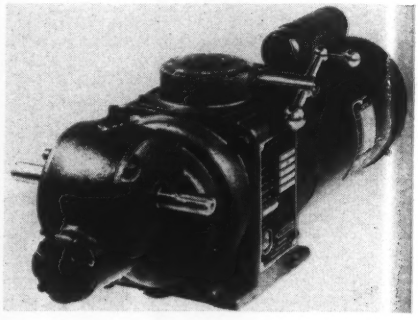


mounted equipment. Damping in any direction is provided. Made by **Lord Mfg. Co.**, 1635 W. Twelfth St., Erie, Pa.

For more data circle MD-74, Page 175

Variable Speed Transmission

Worm reducer assembly is available as standard equipment in Graham 1/6 and ¼-hp infinitely variable speed transmissions. Unit can be furnished with double output shaft extension as shown or

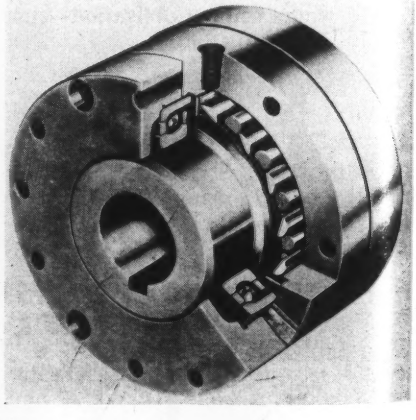


with single shaft extension horizontal or vertical, up or down. Worm ratios of 5:1, 12:1, 23:1, 45:1 and 60:1 provide range of speeds from 550-0 to 10-0 rpm. All speeds are selected by handwheel. Large ball bearings will take heavy thrust and overhung loads. Entire assembly of reducer, transmission and motor, is mounted with four bolts. Various types of built-in motors are available, as are various controls, including remote electrical and pneumatic and hydraulic. Made by **Graham Transmissions Inc.**, Menomonee Falls, Wis.

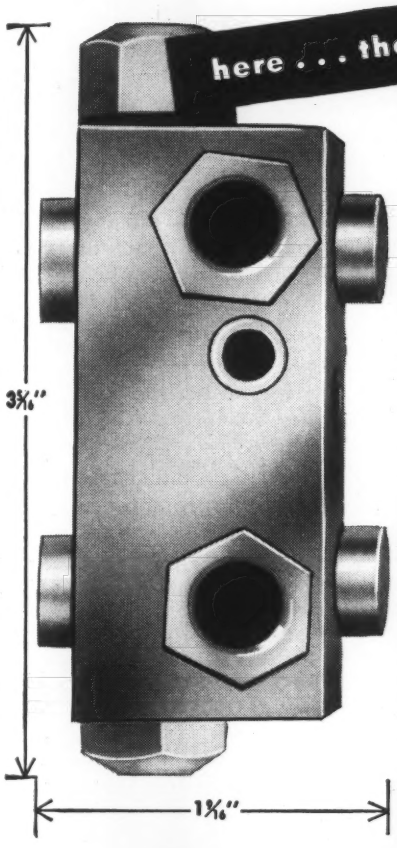
For more data circle MD-75, Page 175

Cam Clutches

Self-contained, MC series general duty cam clutches for overrunning, backstopping and indexing drive applications include two ball bearings that maintain concentricity of inner and outer races. Units have alternate low wedge angle cam and roller construction. Tapped holes in both ends of clutch accommodate cap screws or studs which attach sprockets, gears, pulleys or ratchet arms for drive re-



here . . . the "lubrication fitting" that never forgets!



ALEMITE Accumeter®

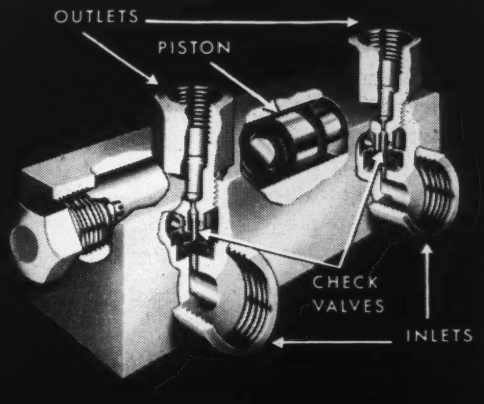
provides automatic, fool-proof lubrication for the heaviest, biggest machines, operating under the toughest conditions . . . indoors or outdoors!

Picture a machine under the toughest job conditions you can imagine. Where bearings operate under the *worst* conditions—in dust, rain, fumes, grit—even completely immersed. Here, ordinary manual lubrication methods would be costly—man-hours would be wasted and production time lost while the machine was shut down for lubrication.

If you were designing this machine, what method could you specify to make sure *every* bearing would always be properly lubricated?

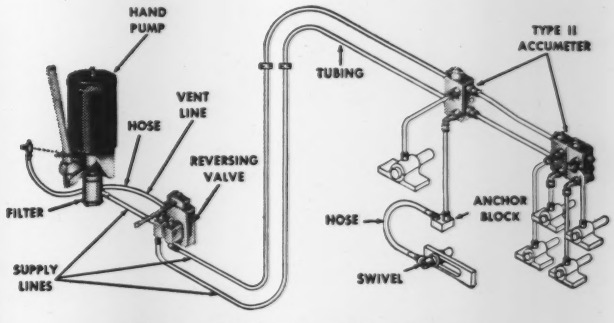
Here's the answer—Alemite Accumeter, the valve that is far more dependable than any man. This simple, completely sealed system delivers an *exact* amount of lubricant where it is needed at *exactly* the right time—*while the machine is in operation!* Time, maintenance and production costs drop—while output soars! No wonder more than 95% of all major plants buying machine tools specify centralized lubrication!

And Alemite Accumeter Systems are easy to design into any machine—and there is a system ready to solve any machine lubrication problem. Find out about these automatic systems now. See for yourself the tremendous savings and efficiency they allow you to offer when you specify automatic Accumeter.



Type II Accumeter Valves

Each serves two bearings. In four sizes delivering from .010 to .500 cubic inch of lubricant. Adjustable. Fully hydraulic—no springs. Completely sealed system serves up to 600 bearings. Manual or power operation.



offers all these advantages!

- Eliminates shut-down time for lubrication. Adds productive time to machine output.
- Seals completely against dirt, grit, fumes, water all the way from "barrel to bearing."
- Prevents bearing troubles due to neglect or wrong lubricant.
- Services all bearings—including those inaccessible or dangerous—in one operation.
- Avoids work spoilage and bearing repairs due to over-lubrication.

factory tested—field proved

Exhaustive, in-the-field tests show no appreciable variation in the amount of lubricant discharged after 73,312 lubrication cycles. Equal to 122 years of twice-a-day service!

Free—*Alemite Accumeter Catalogue*

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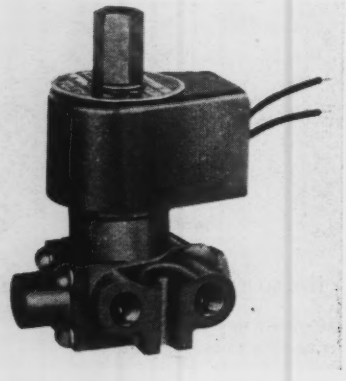
quirements from 60 to 545 lb-ft. Models MC-4000, MC-5000 and MC-6000 are respectively rated 60, 95 and 195 lb-ft for indexing; 120, 190 and 380 lb-ft for overrunning; and 165, 270 and 545 lb-ft for backstopping. Made by **Morse Chain Co.**, 7601 Central Ave., Detroit 10, Mich.

For more data circle MD-76, Page 175

Miniature Solenoid Valve

Measuring $4\frac{7}{16}$ in. high, less than 3 in. long and 2 in. deep, this four-way solenoid valve operates at a maximum of 400 cycles per minute within the pressure range of 10 to 125 psi for ac and to 50 psi for dc. It handles air, water, light oil and other noncorrosive gases and liquids at temperatures to 212 F. Pipe size is $\frac{1}{4}$-in.; orifice diameters are $\frac{1}{16}$-in. inlet, $\frac{3}{32}$-in. exhaust. Standard valve has NEMA type I enclosures with $\frac{7}{8}$-in. diameter clearance holes for standard $\frac{1}{2}$-in. conduit. All enclosures can be rotated 360 deg. Valve body is

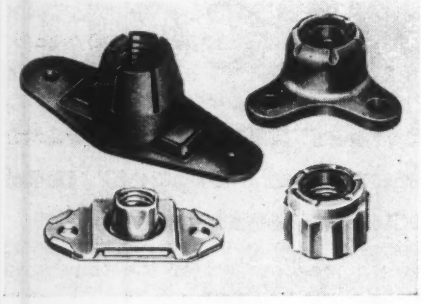


of forged brass, and all metal parts in contact with fluid are either brass or stainless steel. Valve is packless with integral crown seat and nylon disks for tight seating. Poppet type seats and disks prevent sticking. Valve is available with standard, watertight or explosion-proof solenoids. Power consumption is 10 w; standard voltages are 115 or 230 v, 60 cycles ac; 115 v dc. Other voltages and frequencies can be obtained. Made by **Automatic Switch Co.**, 391 Lakeside Ave., Orange, N. J.

For more data circle MD-77, Page 175

Lightweight Locknuts

Four lines of ESNA locknuts have been redesigned to effect a

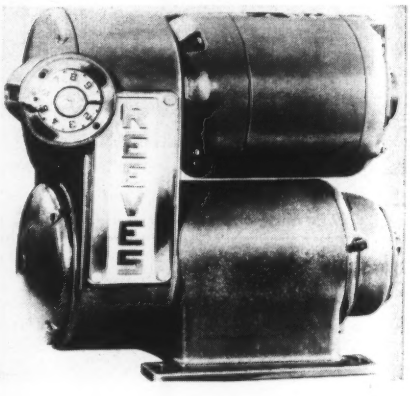


savings in weight. Type ZA1W nuts, upper left in illustration, are made in two series—for use to 800 and to 1200 F. Bodies are made of higher strength stainless steel than that used for lighter, welded-on base. Weight has been reduced about one-third from previous design. High-strength aluminum alloy is utilized in Blue J series nuts, which meet strength specifications for steel nuts but weigh an average of 65 per cent less. Illustrated at upper right is one of the series, which includes hex nuts, fixed and floating anchor nuts and gang channel nuts. Type LH is for service to 550 F. Available in fixed anchor nuts, floating anchor nuts (illustrated lower left), and gang channel nuts, these fasteners have the load-carrying area separable from the locking section, which is nondamaging to bolt or nut threads. Type Y steel nonfixed nuts, lower right, are currently available in sizes from 10-32 through $\frac{5}{8}$-18. Double hex design reduces distance across flats without sacrifice of strength. Nut is about 25 per cent lighter than previous design. Made by **Elastic Stop Nut Corp. of America**, 2330 Vauxhall Rd., Union, N. J.

For more data circle MD-78, Page 175

Variable Speed Drive

Completely redesigned fractional-horsepower Vari-Speed Motodrives are available in $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$ and $\frac{3}{4}$-hp sizes in speeds from 3 to 4660 rpm with 2:1 to 10:1 ratios between maximum and minimum speeds. The smaller, more compact units are available in 112 different assemblies to meet various space requirements and in horizontal, vertical and 45-deg models. Output shafts can be on the motor side, opposite the motor or vertical down. Spiral groove lubrication system provides complete lubrication of all sliding surfaces. An overflow outlet carries any excess lubricant away from disk faces and V-belt. In addition to the standard handwheel, which can be located in six different positions, units are also available with extended handwheel control, electric remote and me-

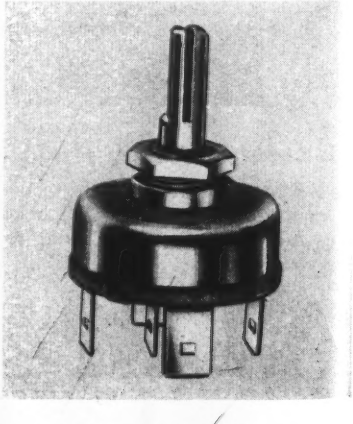


chanical automatic control. Made by **Reeves Pulley Co.**, Columbus, Ind.

For more data circle MD-79, Page 175

Rotary Switch

Designed for a wide variety of applications, 7551 series rotary snap switch is manually operated,



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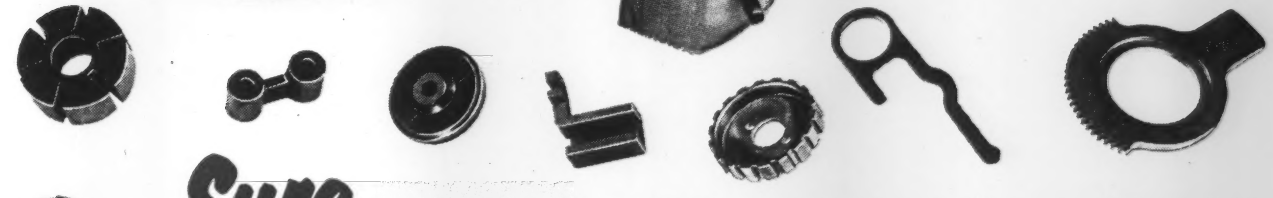

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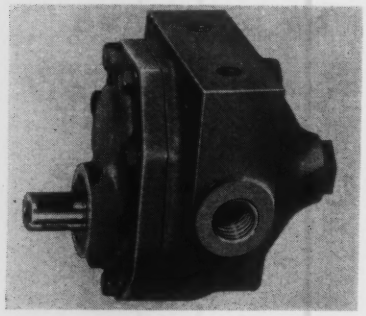
measures 1⅛-in. diameter and requires ¾-in. depth behind the mounting panel. It is Underwriters' listed at 3 amp, 125 v ac. Available in many circuit sequences including tap and accumulative positions, it can be supplied with screw, solder or quick-connect terminals. Standard milled shaft diameter is ¼-in., and shafts are available in any length. Mounting is by threaded stem and hex nut. Made by **Ark-Les Switch Corp.**, 51 Water St., Watertown 72, Mass.

For more data circle MD-80, Page 175

Hydraulic Gear Pump

High-pressure model 051002-110 hydraulic gear pump will produce pressures to 2000 psi. Compact unit

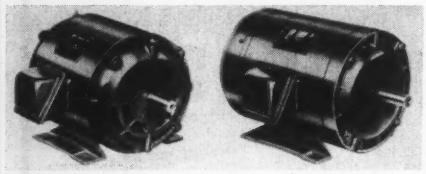


has a capacity of 11 gpm at 2400 rpm with volumetric efficiency to 94 per cent and mechanical efficiency to 88 per cent. It is recommended for intermittent or continuous duty with oil temperatures to 150 F. Made by **Borg-Warner Corp.**, Pesco Products Div., 24700 N. Niles Rd., Bedford, O.

For more data circle MD-81, Page 175

Polyphase AC Motors

Series 100 rerated polyphase ac motors in 1 to 30-hp class are built to new NEMA frame size-to-horsepower standards. In some models horsepower is double that formerly available in frames of the same size. Frames are rolled steel, and end plates are cast iron. Open, drip-proof motors and totally enclosed, fan-cooled motors are available in 182 and 184 frame sizes, rated 1, 1½ and 2 hp at 1800 rpm; 1½, 2 and 3 hp at 3600 rpm; and ¾, 1 and 1½ hp at 1200 rpm. Drip-proof motors have bearing shields to keep out foreign matter and space for almost any standard bearing. Temperature rise within 40 C rating can be maintained. Totally enclosed, fan-cooled motors have pressed-metal guard to enclose the external fan. Cartridge type bearing enclosures allow complete disassembly without exposing the bearing. Motors are equipped with grease fittings and relief plugs and are rated 55 C temperature rise. Made by **Howell Electric Motors Co.**, Howell, Mich.

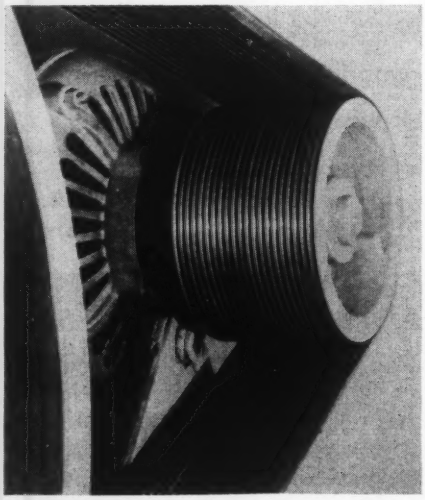


For more data circle MD-82, Page 175

Transmission Belt

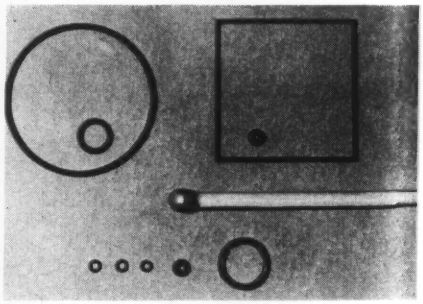
New Poly-V Drive employs single, endless rubber Poly-V Belt, which has a series of parallel V ribs molded lengthwise around the inside circumference. Solid portion of the belt at base of ribs is reinforced with high-strength synthetic cords which run lengthwise and which are closely spaced across entire belt width. Sheave grooves mate precisely with belt ribs, and since the belt covers the full width of the drive member, load is distributed equally over the driving surface. Belt is available in No. 187 and No. 375 cross sections, two sizes which meet all drive requirements from 3-in. pitch diameter sheaves and 50-in. belt pitch lengths. Made by Manhattan Rubber Div., **Raybestos-Manhattan Inc.**, Passaic, N. J.

For more data circle MD-83, Page 175



Subminiature O-Rings

Subminiature O-rings and other microscopic rubber parts for various industrial applications are available in sizes as small as 0.010-in. cross section and 0.020-in. ID, produced by injection molding.



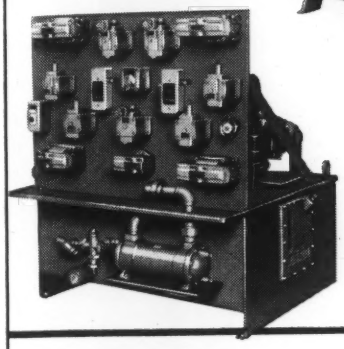
Typical applications are in watch cases, butane gas lighters, electronic cables, water injection carburetor nozzles, small switches and miniature air valves and controls. Properties are the same as for larger counterparts. Made by **Minnesota Rubber and Gasket Co.**, Dept. KP, 3630 Wooddale Ave., Minneapolis 16, Minn.

For more data circle MD-84, Page 175

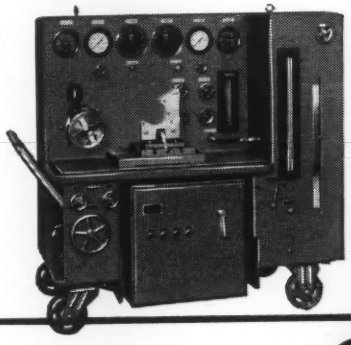
Magnetic Fluid Clutch

Application of direct current to coil of model 731B magnetic fluid clutch transmits torque up to 50 lb-in. It utilizes grease-like lubricant in which fine magnetic particles are suspended. Varying the current causes fluid to stiffen in proportion to the current. This varied torque is much like the varied clutch pressure of a conventional clutch. Direct current may be derived from a vacuum

Pulpit type power unit provides full visibility, easy accessibility.

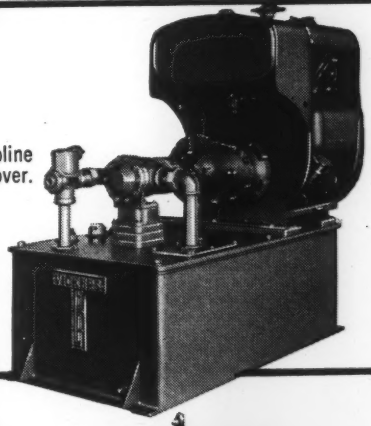


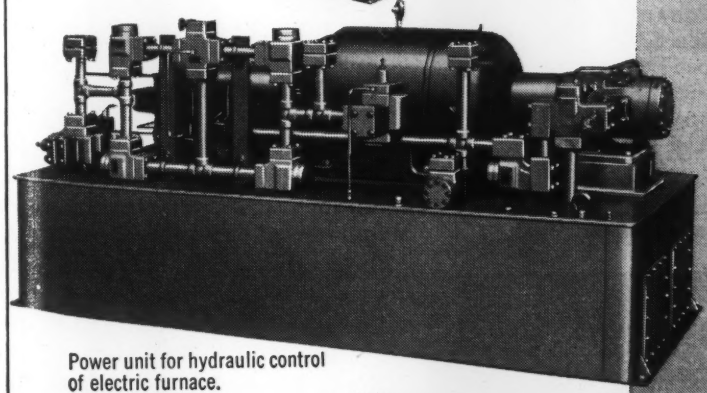
Compact power unit showing gasket-mounted valves.



Portable power unit for testing pumps.

Power unit with gasoline engine as prime mover.





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A Vickers Hydraulic Power Unit includes all necessary pumps, valves, intermediate piping, oil reservoir, motors, controls, etc., as well as all hydraulic accessories (oil filters, air cleaners, oil level gauges, fittings, etc.). Hydraulic connections can be grouped in a convenient manifold.

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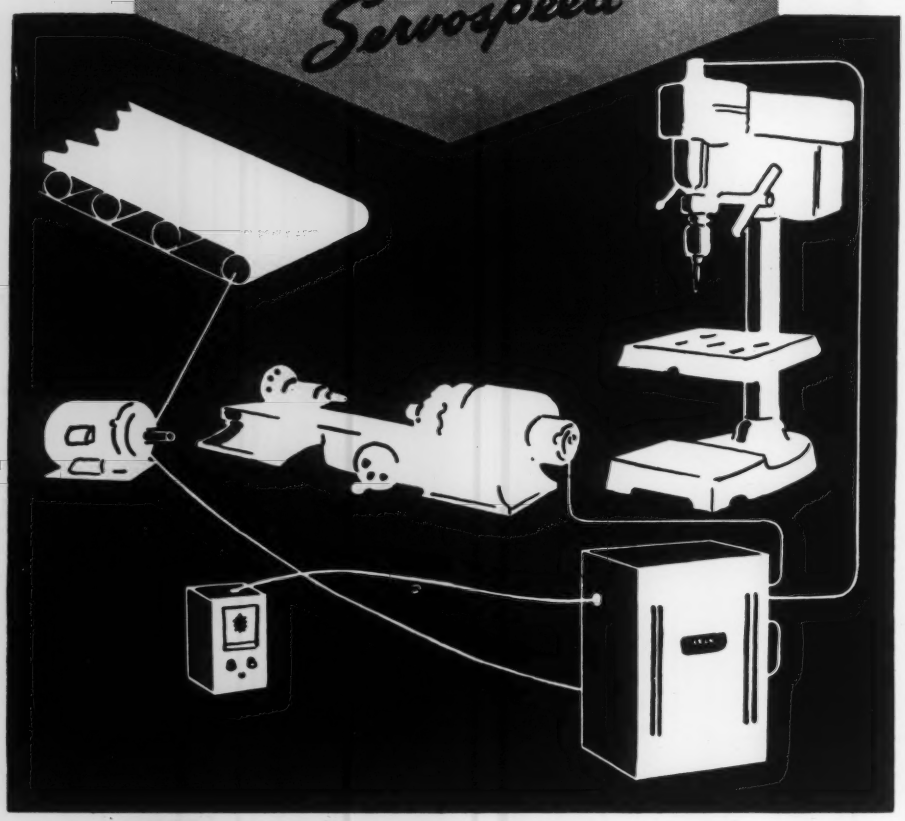
FINGER-TIP MOTOR SPEED CONTROL by Servospeed



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Your application problems for manual or automatic models will receive the prompt attention of our sales engineers.

Servospeed
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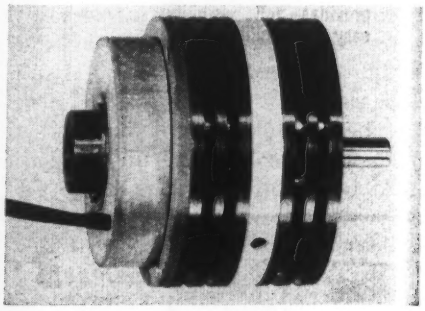
4 Godwin Ave. Paterson, N. J.

New Parts

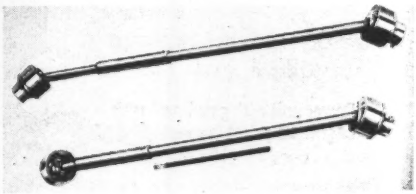


tube or rectifier source. At the maximum recommended speed of 800 rpm, clutch can transmit up to 475 w or 2/3-hp. Unit has ball bearings and fluid seals. It weighs 3½ lb and measures 3¼ in. in diameter and 3 49/64 in. long. Made by **Raymond Engineering Laboratory Inc.**, Smith St., Middletown, Conn.

For more data circle MD-85, Page 175

Universal Joint

Miniature, lightweight constant-velocity Rzeppa universal joint has an adjustable length shaft. Angularity of the joint is 0 to 40 deg, depending on speed and torque.



Compact unit delivers a uniform flow of power. Made by **Gear Grinding Machine Co.**, 3901 Christopher Ave., Detroit 11, Mich.

For more data circle MD-86, Page 175

Aluminum Solder

Core of AluTin 51 solder for production, filling, sealing and repair operations upon wrought and cast aluminum alloys is a liquid flux with good wetting properties. It reduces surface tension and permits the alloy to spread and flow out wherever the flux has wet the surface. Accelerated tinning action facilitates bonding and permits high strength, porosity-free de-

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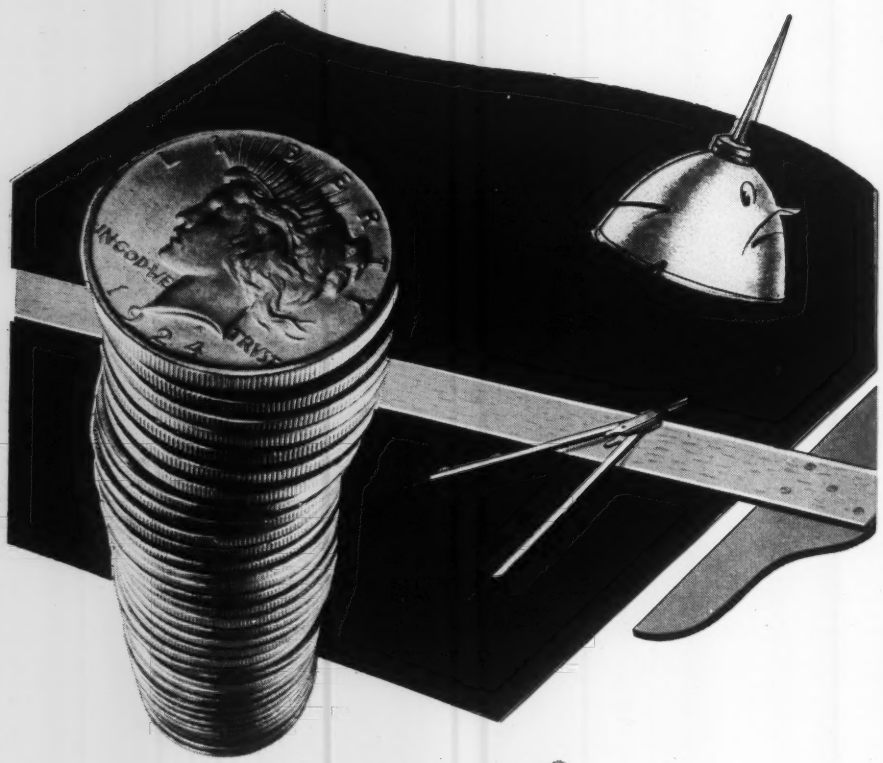

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Pioneers in Automatic Lubrication

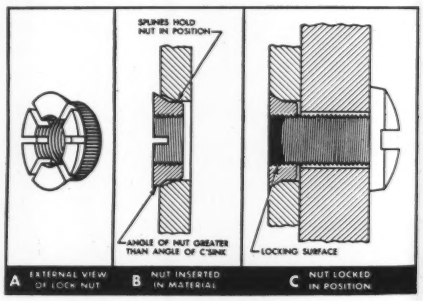
New Parts

posits. Melting range is between 400 and 500 F and tensile strength is up to 7000 psi. Any type of heat source may be used, including soldering iron. Alloy can also be used on steel and other metals. Made by **Eutectic Welding Alloys Corp.**, 40-40 172nd St., Flushing 58, N. Y.

For more data circle MD-87, Page 175

Locknut

Designed for insertion in a countersunk hole, solid metal locknut is of slotted cone shape at one end and is a splined cylinder at the other end. Nut is partially or completely seated and held in position by force-fitted splines. After insertion of bolt, locking action is effected by pressure of the sector threads forced against the bolt by interference of the countersinks.



Locking action is not affected by high temperatures, and nut remains in position and retains locking action after removal of bolt. Nut is available in all metals and all standard thread specifications. Made by **Allmetal Screw Products Co. Inc.**, 821 Stewart Ave., Garden City, L. I., N. Y.

For more data circle MD-88, Page 175

Rotary Solenoid

Model BD4 Ledex rotary solenoid measuring $1\frac{9}{16}$ in. in diameter, is available in 25, 35, 45, 67½ and 95-deg rotation models either clockwise or counterclockwise, with starting torques to 5.39 lb-in. In operation, the magnetic pull moves an armature along the solenoid axis, this linear action being converted into rotary motion by

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Take your choice! . . . Get Miller quality famous "Custom-Built" Air Cylinder available on normal, scheduled deliver in an *infinite selection* of bore-and-strok combinations in 14 standard mountings . .

. . . Or get identical quality "Stock" Mille Air Cylinders *ready for immediate shipment to you* in these popular sizes, stroke and mountings . . .

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"Stock" Cylinders are base Model A5 with foot, flange, and pivot mounting at tachments available as desired.

NOTE: "Stock" Miller Hydraulic Cylinders also available!

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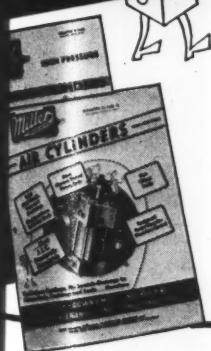
minate Rust and Corrosion



WRITE FOR CYLINDER BULLETINS A-105 and H-104

Complete Miller cylinder line includes: air cylinders, 1½″ to 20″ bores, 200 PSI operation; low pressure hydraulic cylinders, 1½″ to 6″ bores for 500 PSI operation, 8″ to 14″ bores for 250 PSI; high pressure hydraulic cylinders, 1½″ to 12″ bores, 2000-3000 PSI operation. All mounting styles available.

MET J. I. C. PNEUMATI STANDARDS years befor their adoption in 1950.

SPACE-SAVING SQUAR DESIGN originated by Mille in 1945.

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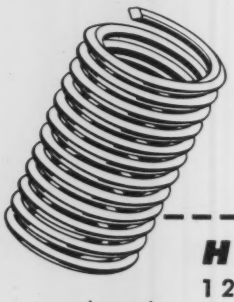
These 18-8 stainless steel or phosphor bronze ***Heli-Coil*** Inserts give you a minimum of 25% greater loading strength... your threads will *never* seize, corrode, or gall... you save space, material and money because you can use fewer, smaller, shorter fastenings and lighter, cheaper materials... and smaller bosses and flanges.

It will pay you to investigate the many advantages ***Heli-Coil*** Screw Thread Inserts offer. Write today for full information, free samples and, if you wish, the assistance of a ***Heli-Coil*** Thread Engineer.



***Heli-Coil* Inserts conform to official Military Standards MS-122076 (ASG) through MS-124850 (ASG) and others.**

* Reg. U. S. Pat. Off.

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☐ Send samples and Bulletin 689 — Military Standard Sheets.
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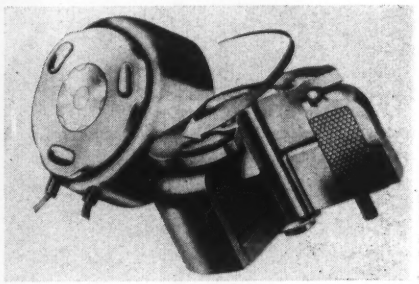
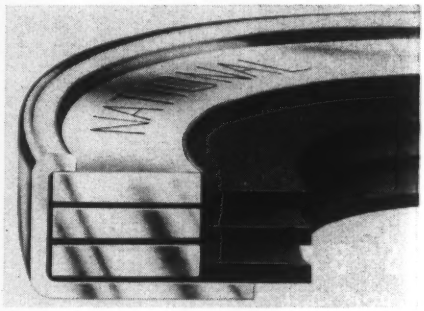


means of ball bearings on inclined races. Resulting rotary snap-action power is harnessed with a minimum of linkages. Made by **G. H. Leland Inc.**, Dayton 2, O.

For more data circle MD-89, Page 175

Bearing Oil Seal

Bearings of agricultural and other heavy duty equipment are protected from extreme dirt and dust conditions by the Triple-Lip Syntech seal. Unit consists of three identical lips of synthetic rubber bonded to steel washers



and enclosed in a rigid steel outer case. Design keeps seal torque low, simplifies flush lubrication and enables the seal to handle large amounts of shaft runout and misalignment. Seals also reduce frequency with which lubrication is required. Made by **National Motor Bearing Co.**, Broadway at National Ave., Redwood City, Calif.

For more data circle MD-90, Page 175

Miniature Clutches

Series of miniature clutches for overrunning, backstopping and indexing consists of four models which have all the characteristics

Case History M-125

Here's what we mean by *SUPERIOR* ENGINEERED FOUNDRY PRODUCTS...

Problem

CONVENTIONAL CASTING SHAPE . . .

1. Had critical stress concentration.
2. Had load carrying capacity of 1,450 pounds; was inadequate for service requirements.
3. Was dimensionally unstable.
4. Was conducive to poor quality.

Our Solution

SUPERIOR FOUNDRY ENGINEERED DESIGN utilized the inherent advantages of the cast process and developed a proper shape for improved function, strength, castability. The new design, based on the results of experimental stress analysis, required the addition of only a few ounces of metal at strategic points.

Results

PROPER CASTING SHAPE . . .

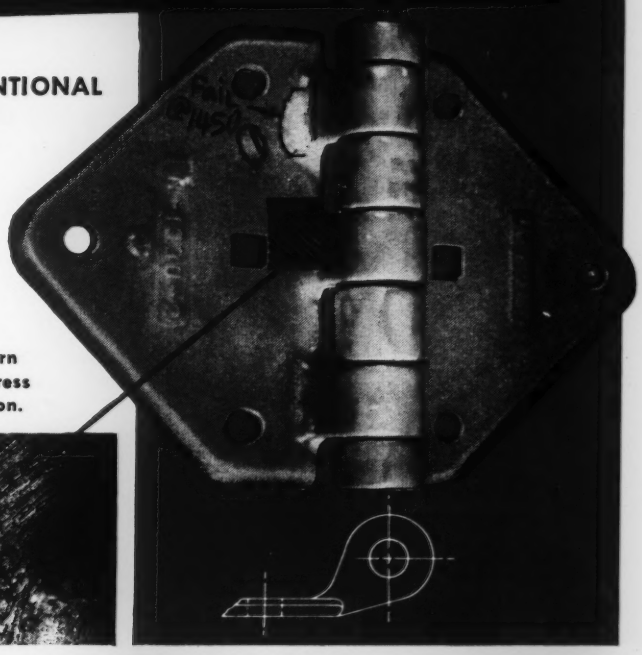
1. Has reduced stress concentration 65.9%—has obtained uniform stress distribution.
2. Has load carrying capacity 2.5 times greater.
3. Is dimensionally stable.
4. Assures quality, at no increase in cost.

SUPERIOR'S PRODUCT DEVELOPMENT SERVICE is here to help solve your design problems, to help save you time and money. This service develops the best design for your parts.

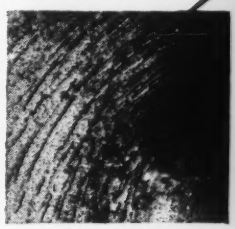
SUPERIOR'S PRODUCT DEVELOPMENT SERVICE deals with *FACTS* not *OPINIONS*, so why not take advantage of this service to make even your BEST products BETTER.

Make your parts Superior Engineered Foundry Products . . . malleable iron castings to 300 pounds . . . steel castings to 30,000 pounds.

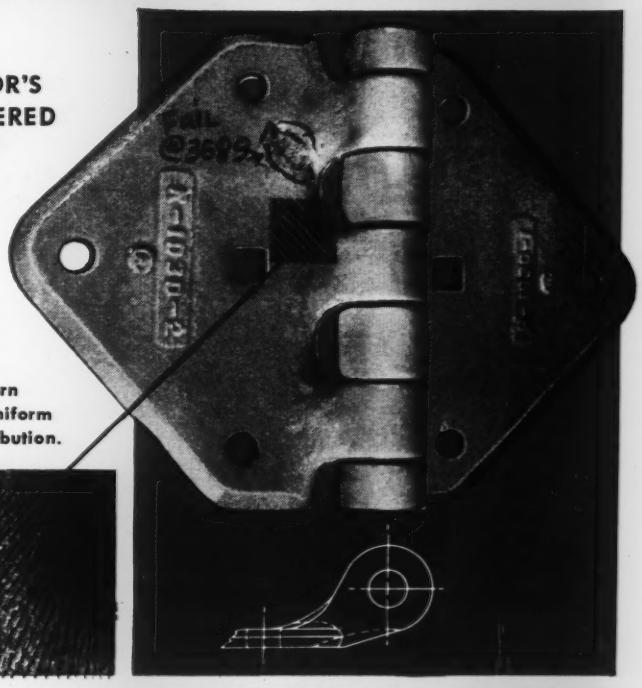
CONVENTIONAL DESIGN



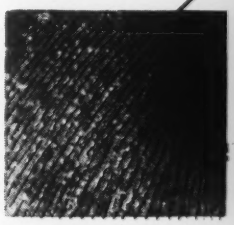
Strain pattern showing stress concentration.



SUPERIOR'S ENGINEERED DESIGN



Strain pattern showing uniform stress distribution.



Have you entered the first annual Product Development Contest sponsored by the Steel Founders Society of America? We'll be happy to send you the details.

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DETROIT 7, Sales Engineering Corp., 955 E. Jefferson Ave.
BUFFALO 21, Gibney-Decot Corp., 2107 Kensington Ave.
CLEVELAND 14, C. A. Lapp & Co., 1404 East 9th Street

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SUPERIOR STEEL AND MALLEABLE CASTINGS CO.

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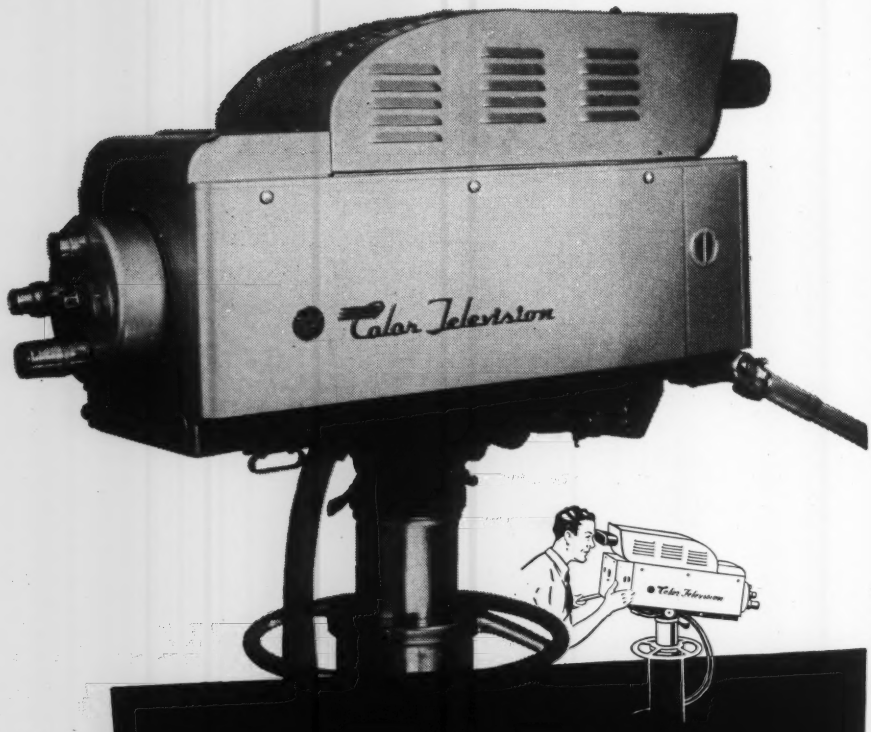

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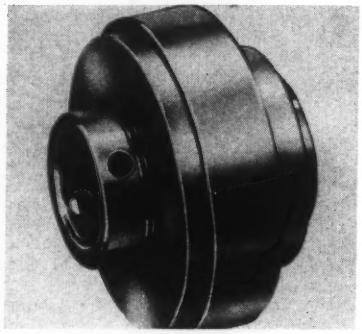
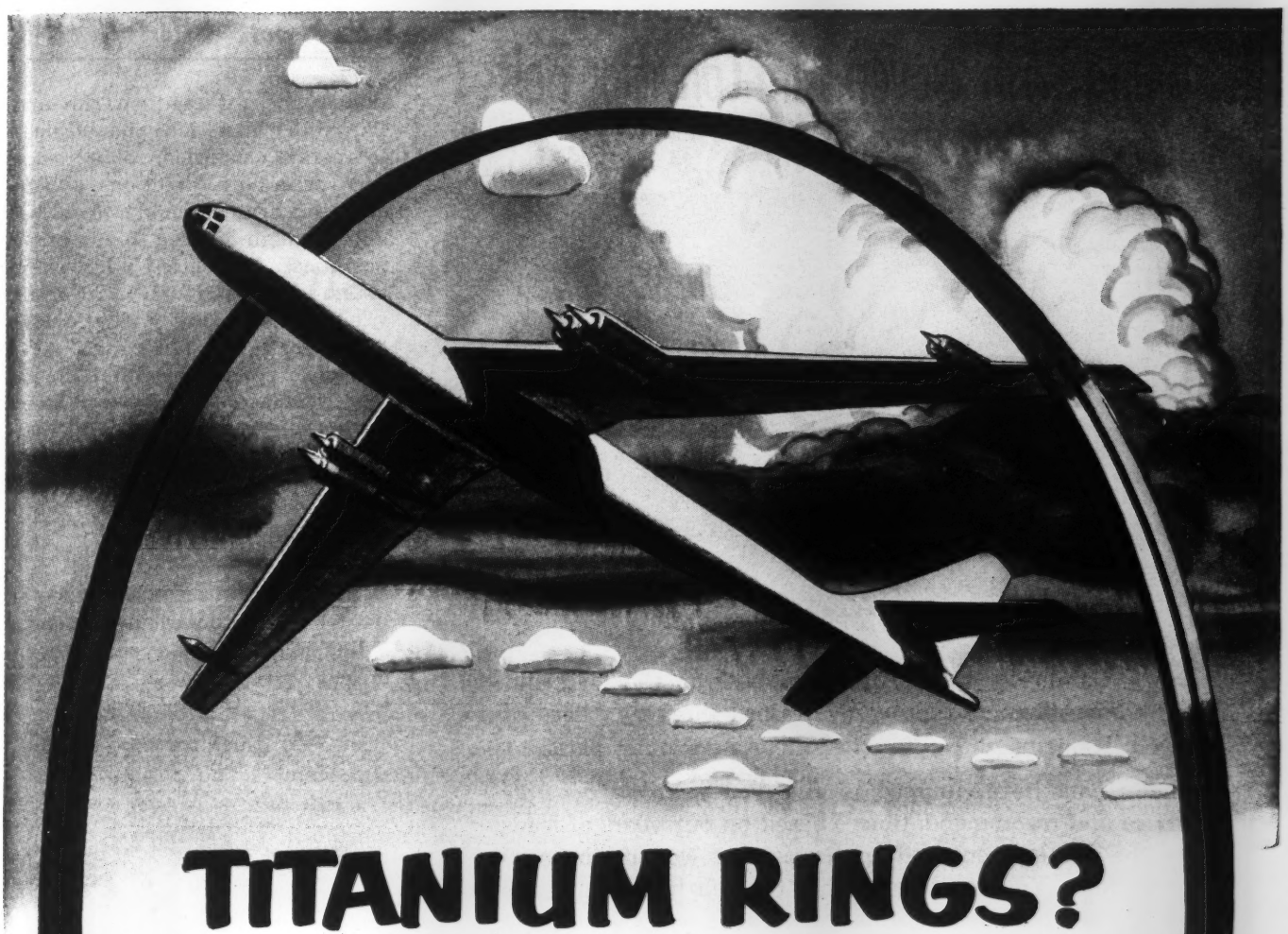


of the full complement sprag principle. Clutches have been standardized and combine small size with high torque capacity. Standard bore sizes are ¼, ⅜ and ½-in. Made by **Formsprag Co.**, 23601 Hoover Rd., Van Dyke, Mich.

For more data circle MD-91, Page 175

Sealed Limit Switch

Heavy - duty precision limit switch, designated 51MLI, can be used where dust, dirt, abrasives or liquids are present. Entire housing, including the operating head with actuator and return mechanism, is sealed. Unit's die-cast enclosure also provides protection for the replaceable switching unit. Switch may be mounted in almost any position in relation to the means of actuation. Operating head is adjustable to any of four horizontal positions, and the roll-



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If you use, or are planning to use, fabricated Titanium components, let our Product Development Division study your problem. Our factory is equipped to perform welding, machining, and fabricating of all types of ferrous and non-ferrous metals.

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Every Cambridge Sales Engineer—both in the field and the home office—is thoroughly trained in every phase of wire belt engineering before he enters a customer plant.

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OFFICES IN LEADING INDUSTRIAL AREAS

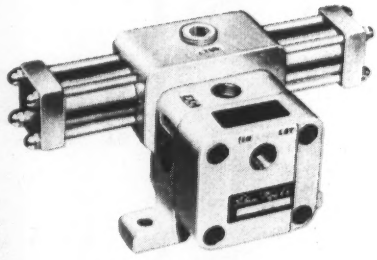
New Parts

er may be reversed on the arm. The roller arm may be adjusted to operate clockwise, counterclockwise, or in both directions, and the actuator arm assembly is adjustable through 360 deg to any of 870 positions. Switch is Underwriters' listed for 20 amp, 110, 220 or 440 v ac; ½-amp, 115 v dc; ¼-amp, 230 v dc; ¾-hp, 110 v ac; 1½ hp, 220 v ac. Made by Micro Switch Div., **Minneapolis-Honeywell Regulator Co.**, Freeport, Ill.

For more data circle MD-92, Page 175

Power-Operated Valves

Designed for actuating remotely located or automatically operated cylinders, two disk type power-operated valves are available in two and three-position types. They



have free-floating piston movement; floating piston bar; pilot valves, permitting many interchangeable control combinations; and power return to all positions, eliminating the use of springs. Valves are made of corrosion resistant materials and can be operated by air, gas, oil or water. They are built in ⅜ to 1¼ in. sizes for standard pipe connections. Made by **Ledeen Mfg. Co.**, 1600 S. San Pedro St., Los Angeles 15, Calif.

For more data circle MD-93, Page 175

Electrical Counter

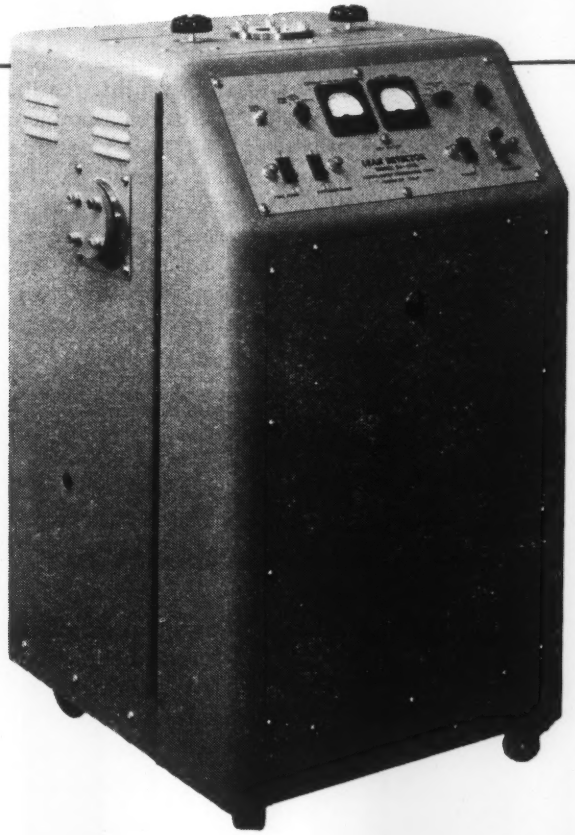
Electrical-reset Sodeco counters are reset to zero in 0.4-second and are available in four or five-digit models. Standard models have counting speeds to 10 impulses per second, and special models are available with speeds to 25 im-

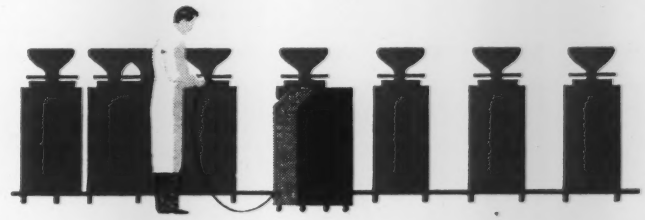
Sensitive to 1 part in 2,000,000

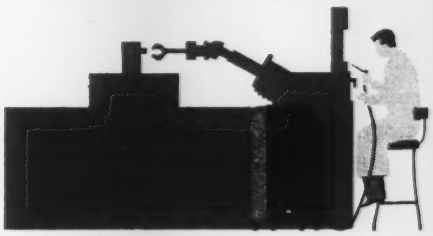
Consolidated's new Model 24-110 Leak Detector

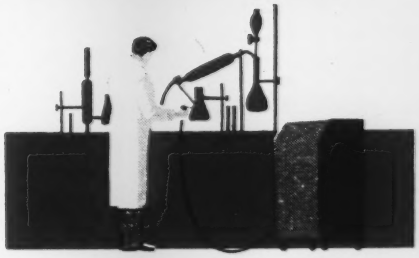
For leak detection applications where the utmost in sensitivity is required, Consolidated's new Model 24-110 Leak Detector meets the most stringent requirements. The latest addition to the Consolidated leak detector line is a modification of a high precision instrument built by CEC for the Atomic Energy Commission. Operating on the mass spectrometer principle made famous by CEC's widely used Model 24-101A industrial leak detector, the sensitivity of the 24-110 has been multiplied by a factor of 10 through advanced electronic techniques. Its uses include testing of both evacuated and pressurized equipment, revealing the existence or the absence of leaks, finding the locations of leaks, and determining the rates of leakage. Outstanding features include: an audible alarm whose sound-pitch varies with the magnitude of the leak; an accessory sampling probe for rapid pressure-system leak testing; a selector switch that provides six ranges of sensitivity; a visual leak-rate meter capable of indicating the presence of 1 part helium in 2,000,000 parts air. Compact, self-contained and mobile, Consolidated's new Model 24-110 Leak Detector is a perfect tool for highly critical applications such as detection in ultra high vacuum laboratory equipment, leak-checking of TV color tubes, and safety control in nuclear material manufacturing.

Request Bulletin CEC 1838-X3









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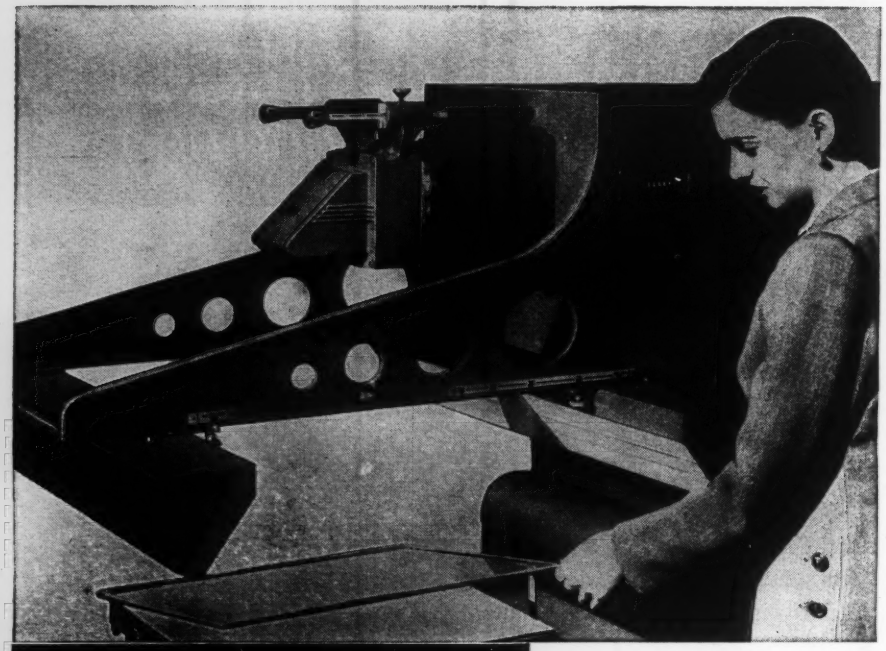

RESET TIMER INSURES ACCURATE PHOTOCOPYING ON REMINGTON RAND DEXIGRAPH

An outstanding feature of this versatile photocopying machine is the Cramer Reset Timer, which controls exposures to split-second accuracy and ensures copy prints of absolutely uniform quality. The Type RE Reset Timer is an ideal choice for this application. Its micrometer adjusting dial allows time settings to be changed easily and quickly; yet setting can be made to a high degree of accuracy. A double pointer system is used which indicates not only the time setting but also the time remaining during any particular cycle. The push-button for starting the timing cycle is right on the front of the timer; a flick of the finger controls the machine. The convenient one-hole meter-type mounting also makes for easy assembly in your factory. Note, too, how well the timer blends in with the design of the machine itself.

Remington Rand is only one of the many large equipment manufacturers who look to Cramer when they have a problem in time control. Cramer has a timer for almost any need, ranging from the simplest interval timers up to complex multi-circuit types. Why not consult Cramer for *your* timing needs?

Cramer TIMING DEVICES

SPECIALISTS IN TIME CONTROL

The R. W. CRAMER CO., *Inc.*

BOX 6, CENTERBROOK, CONNECTICUT

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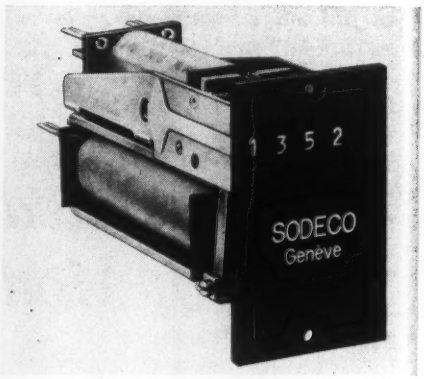
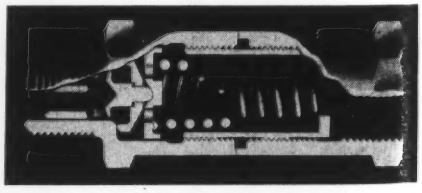


pulses per second. If necessary, reset voltage can be different from the impulse voltage. Compact counters are suitable for flush mounting and measure 1⅜ x 2⅜ x 4⅜-in. They are available with or without housings. Available from **Landis & Gyr Inc.,** 45 W. 45th St., New York 36, N. Y.

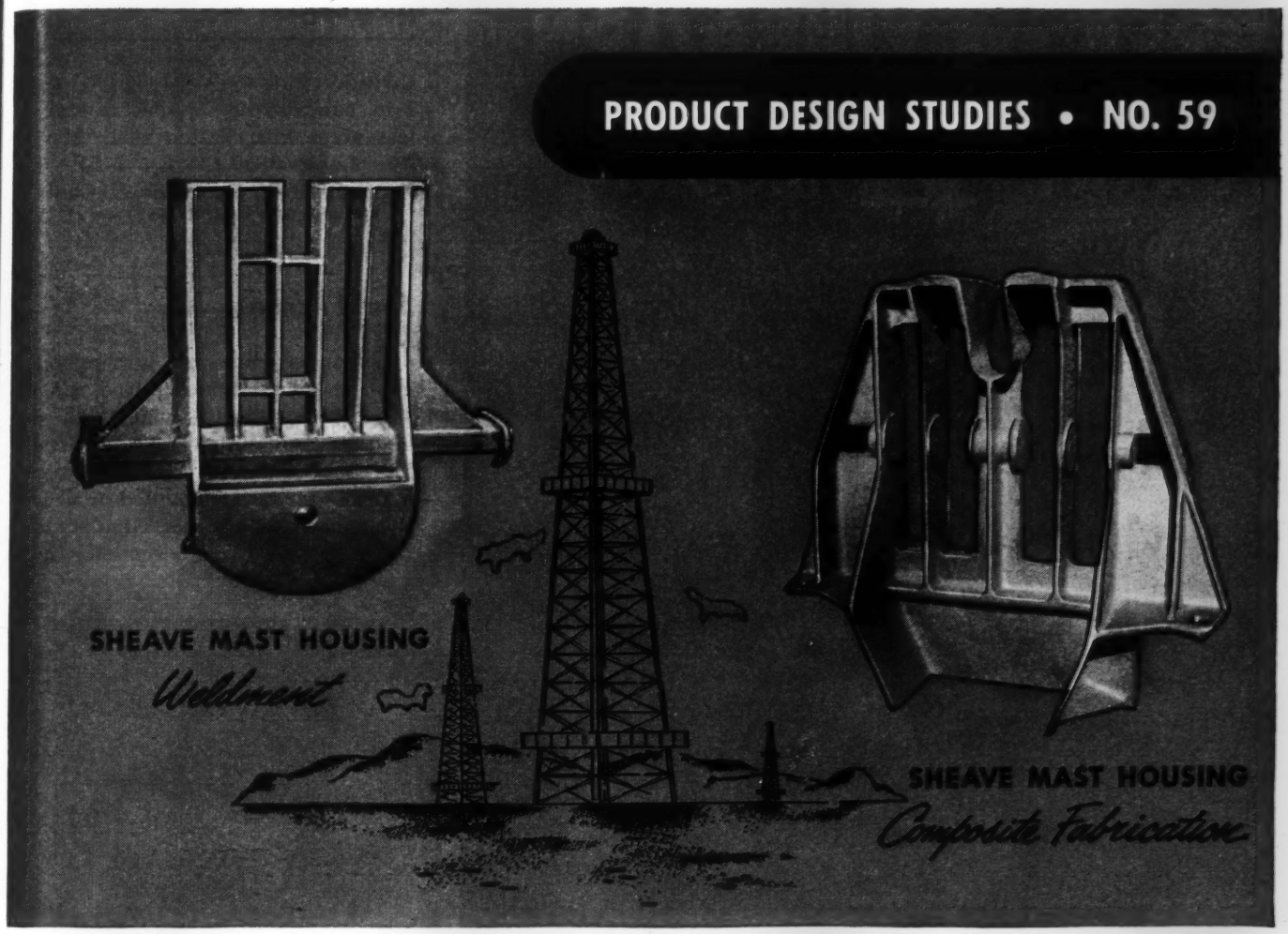
For more data circle MD-94, Page 175

Relief Valve

For service at 50 to 1000 psi pressure in most gases and liquids, Circle Seal 5100 series valve is compact and lightweight. In-line construction facilitates mounting and provides good flow characteristics without pilot operation. Pressure drop increases slightly but regularly with increasing flow rate, stabilizing the action and imparting smooth, quiet operation. An O-ring seal and a spring centering device



which allows transmission of only axial force to the poppet, provides sensitive operation combined with durability. Valve does not leak within 2 per cent of preset cracking pressure and reseats without leakage within 5 per cent of the setting. Cracking pressure can be adjusted within ±15 per cent of nominal pressure. Valve is available in either steel or brass with male inlet and female outlet pipe



Appearance Improved, Assembly Simplified By Redesigning To Composite Fabrication

This sheave mast housing is part of an oil well derrick. It goes on top of the mast on a spudding rig and carries the sheaves which handle the line used in drilling and working the well.

Originally produced as a weldment, the manufacturer was enthusiastic about converting the structure to a composite assembly because of the great improvement in appearance. (Structure is a steel casting with two plates welded in the front and lower section.)

Redesign also reduced the weight 10%, made the unit much easier to assemble, and increased durability and strength.

* * *

Here is another example of the steel foundry cooperation which is resulting in lower costs and improved products through redesign to cast-weld or composite assemblies.

This service is offered without cost or obligation. It makes available through your foundry representative the full results of the development and research program carried on by the Steel Founders' Society of America.

Product Development Contest...

Two awards of $1000 each and four other cash awards—a total of $3500. Entries to be new ideas or applications of steel castings, and case histories of new jobs put into production. Write for folder giving full information.

52 YEARS OF SERVICE TO INDUSTRY

STEEL FOUNDERS' SOCIETY OF AMERICA

920 Midland Building **Cleveland 15, Ohio**

Design and Build With Steel Castings

for control of

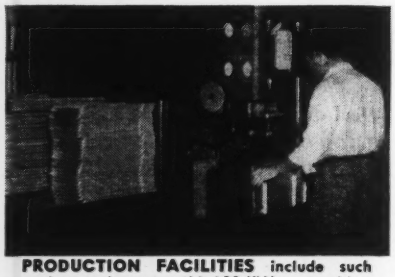
SHOCK and VIBRATION

BARRY B MOUNT

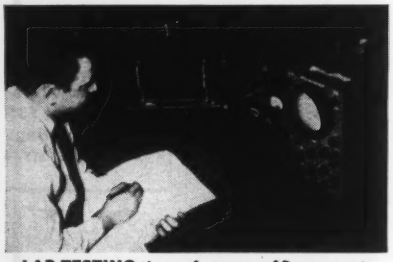
They're YOUR designers - but WE pay them.

You don't have shock and vibration problems every day — but when you *do*, you want them solved promptly. So you want the practical experience of men who've been spending *all* their time in this highly specialized engineering — men who have most likely met and successfully answered questions just like the ones that are bothering you. These men are Barry engineers — ready and able to analyze *your* shock and vibration problems, backed by a laboratory staffed and equipped to *prove* their solutions, and served by model shops geared to produce *your* prototypes whenever you need them.

You'll save time, money, and trouble by using our design and prototype service. Write today for Bulletin DP-54 "This is Barry".



PRODUCTION FACILITIES include such modern equipment as this 100 KVA spot welder, accurately timed for welding aluminum.



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SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

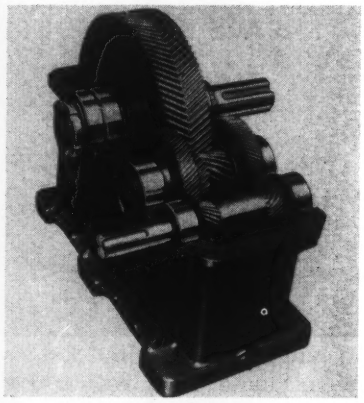
New Parts

threads. Sizes ¼, ½, ⅜, ¾ and 1 in. can also be supplied in stainless steel with Teflon seal. Made by **James-Pond-Clark,** 2181 E. Foothill Blvd., Pasadena 8, Calif.

For more data circle MD-95, Page 175

Speed Reducer

Expanded line of herringbone gear speed reducers in the range from 1 to 1950 hp is available in 60 standard ratios ranging from 1.27:1 to 355.8:1. All units are suitable for either coupled or overhung load applications. Nine standard shaft extension assemblies and



two standard styles of bed plates provide a wide variety of drive arrangements. Units have precision generated herringbone gearing of high hardness; symmetrical, balanced gearing and bearing arrangement; antifriction bearings throughout; high-test alloy iron housings; large openings for inspection and accessible oil drains and oil level indicators. Made by **W. A. Jones Foundry & Machine Co.,** 4401 W. Roosevelt Rd., Chicago 24, Ill.

For more data circle MD-96, Page 175

Protective Coatings

Applied in the same manner as paint, Markal heat-proof protective coatings protect metal surfaces against scaling and corrosion at high temperatures. Coatings are available for protection of metals against hot acids and mild alkalies, against corrosion and scaling at

A AVAILABILITY

S SERVICE

Q QUALITY

you get all three with

B & W CARBON STEEL

SEAMLESS

MECHANICAL TUBING

A AVAILABILITY

Buying convenience through a single source of hot-finished and cold-finished carbon steel tubing, produced in a wide range of grades and sizes.

S SERVICE

You can save through the dependable assistance of B&W Regional Representatives and qualified distributors, trained to help solve fabrication problems and to assist in tube selection.

Q QUALITY

Mechanical properties, machinability, tolerances and surface finishes combined for ease of fabrication in your specific application.

remember A S Q *is meant for you.*

B&W SEAMLESS and WELDED TUBES

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

TA-4048 (CSM)

Townsend made this automotive part at a savings of $18,000 per year

Big savings turn up in unexpected places when you examine the cost of producing small parts and fasteners. That's what happened when a Townsend engineer suggested that this small spacer stud could be produced by the Townsend method of cold-forming at one-third the cost of the former method. Result—a cool $18,000 clipped from production costs and a tougher, stronger part.

This is possible because the Townsend method is fast. And all the raw material went into the part, none was cut away as scrap. As a result, more pieces per pound of metal were produced, resulting in additional economy.

Townsend parts have high resistance to shock and fatigue because cold-forming increases tensile strength. The flow lines of the metal follow the contours of the piece instead of remaining in a single plane, as with machined parts. Cold-forming strengthens the threads and eliminates stock notching. Close size tolerances and excellent surface finish are characteristic of Townsend parts.

As "The Fastening Authority," Townsend produces 60-million pieces daily—regularly makes more than 10,000 special and standard fasteners and parts. With this capacity and the experience of 138 years of metal working to draw upon, Townsend engineers will help you reduce your material and assembly costs. Ask to have one of them call. For more information use the coupon below or write for illustrated bulletin.

Townsend
COMPANY • ESTABLISHED 1816
NEW BRIGHTON, PENNSYLVANIA
Sales Offices in Principal Cities
Cherry Rivet Division • Santa Ana, California

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TOWNSEND COMPANY
Sales Department
New Brighton, Pa.

Please send without obligation "Special Cold-Formed Fasteners and Small Parts" Bulletin TL-89.

Name_____ Title_____
Company_____
Street_____
City_____ Zone_____ State_____

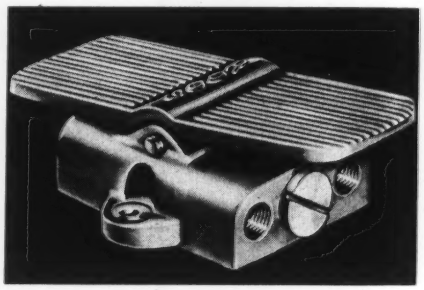
New Parts

temperatures to 1850 F, and against scaling and oxidation to 1200 F. Made by **Markal Co.**, 3052 W. Carroll Ave., Chicago 12, Ill.

For more data circle MD-97, Page 175

Air Control Valve

Available in ¼-in., three or four-way models with two-position locking action, 600 series hand and foot-operated valves have single or double foot treadle and vertical or horizontal hand lever control.

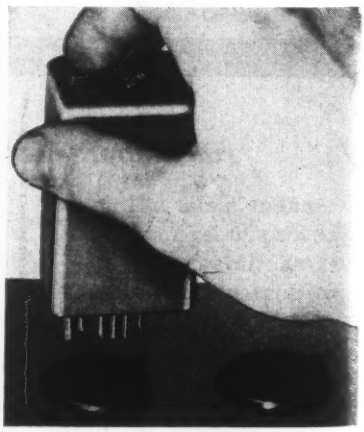


Valve is suitable for small air cylinder use on machines requiring easy operation, continous high production and compactness. Made by **Ross Operating Valve Co.**, 120 E. Golden Gate, Detroit 3, Mich.

For more data circle MD-98, Page 175

Time Delay Relay

Type F Silic-O-Netic time delay relay, combining the hydraulic-magnetic silicone operating principle with plug-in construction, is compact, lightweight and hermetically sealed. An inert gas fill is



Control knob and component parts for Automatic Electrolux cleaner molded by **Mack Molding Co.**, Arlington, Vt.

PLASTIC DIAL TUNES IN A NEW SELLING POINT

You turn this plastic dial knob on the new Automatic Electrolux vacuum cleaner to adjust the cleaner for the dirt condition of the locality in which it is to be used. When collected dirt threatens to lessen air flow, an automatic "brain" stops the motor and ejects the paper dust bag, sealed and sanitary. Put in a new self-sealing bag, and the cleaner runs with full power.

The knob and its component parts that set the automatic "brain" are molded from BAKELITE C-11 Plastic, an acrylonitrile-styrene copolymer. This plastic has good impact strength, withstands heat, and is resistant to oil and most chemicals.

BAKELITE C-11 Plastics are readily molded into intricate, accurate working parts. Their dimensional stability is excellent. They can be sawed, milled, drilled, tapped. They have excellent resistance to soaps, detergents, most acids, alkalies, foods, and fruit stains.

That's why so many industrial and consumer items can be improved in design, sales and service through their use. Learn how they can fit your product by writing Dept. XP-52.

BAKELITE
TRADE-MARK
C-11 PLASTICS

TRADE MARK

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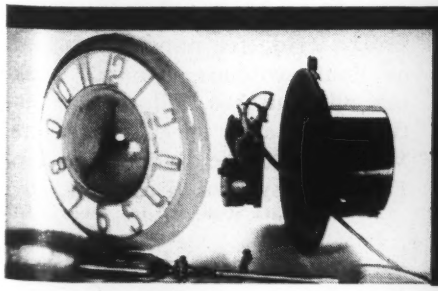
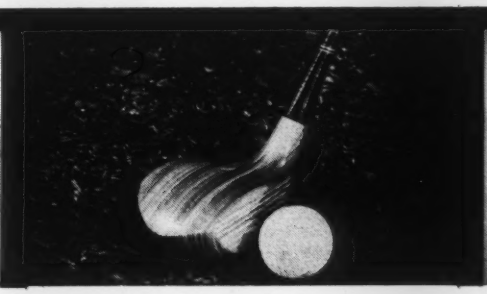
A Division of
Union Carbide and Carbon Corporation
UCC
30 East 42nd Street, New York 17, N. Y.

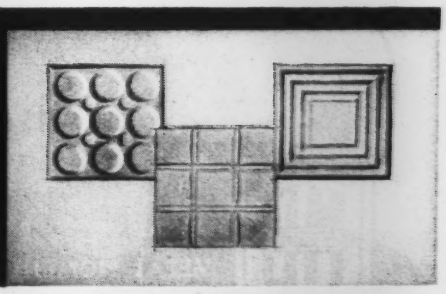
In Canada: Bakelite Company
Division of Union Carbide Canada Limited
Belleville, Ontario



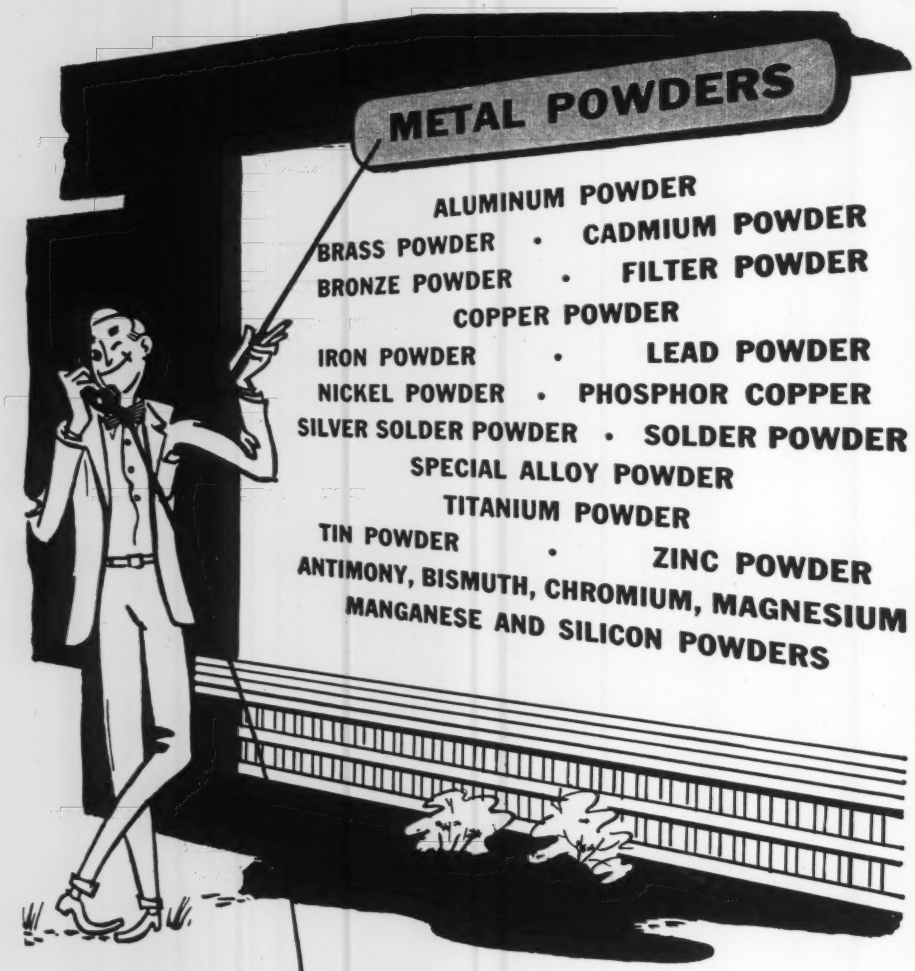
FACE AND COVER for electric clock are BAKELITE C-11 Plastic, an acrylonitrile-styrene copolymer. Finely detailed, tough, brilliantly colored, they combine structural and decorative functions. Molded by Telechron Dept. of General Electric Co., Ashland, Mass.



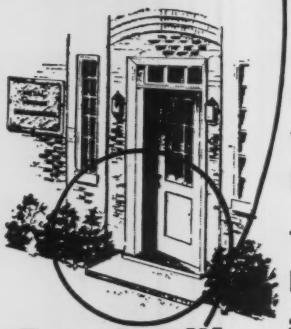
EXTRA-STRONG CLUB HEADS are carved from densified wood produced by forcing BAKELITE Phenolic Resins into wood cells. They resist moisture, temperature change, shrinking, cracking. Need no coating. Made by Albert S. Liebers Co., New York 7, N. Y.



TRANSLUCENT CEILINGS made from these formed BAKELITE Rigid Vinyl Sheet panels are suspended below fluorescent fixtures, diffusing glareless light throughout room. Light weight permits easy removal for cleaning. Made by Daylight Ceiling Co., San Francisco 7, Calif.



One Call—



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WORLD'S LARGEST MANUFACTURER OF FINELY DIVIDED METALS

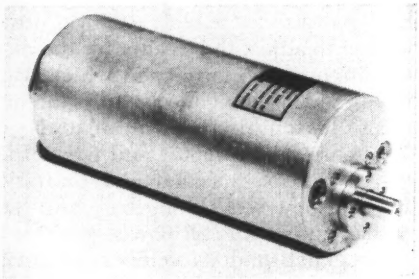
New Parts

optionally available. The relay is provided with standard delay periods from ¼ to 120 seconds. Armature and switch contacts and movable iron core, which is the complete time element, are the only moving parts. Core is hermetically sealed in a nonmagnetic metal tube extending through and beyond a solenoid coil. Relays are furnished with either octal-pin or solder-lug terminals for operation on 24 to 220 v ac or 12 to 125 v dc. Contact capacity is 3 amp at 120 v ac or 1 amp at 50 v dc. Single-pole, single-throw; single-pole, double-throw; double-pole, single-throw; or double - pole, double - throw switching actions are available. Made by **Heinemann Electric Co.**, 572 Plum St., Trenton 2, N. J.

For more data circle MD-99, Page 175

Miniature Actuators

High-torque rotary actuators measure 2 x 5 1/16 in. and have capacity of up to 2000 oz-in. torque, depending upon output speed. Voltage ranges vary from 6 to 100 v. Units can be arranged



for different speeds, torques and degrees of angular rotation and can include reversing relays. They can be made for applications such as limit switches, dynamic braking, slip clutches, follow-up potentiometers and speed governors. Made by **Globe Industries Inc.**, 1784 Stanley Ave., Dayton 4, O.

For more data circle MD-100, Page 17

Variable Speed Drive

Speed is varied by changing the location of the counter-shaft be-

TORQUE CAPACITIES FROM this

you'll get dependable, smooth power delivery when you specify

BLOOD BROTHERS

Universal Joints

FOR AGRICULTURAL, AUTOMOTIVE, INDUSTRIAL, MARINE AND CONSTRUCTION EQUIPMENT APPLICATIONS

K Series K2R Series	Maximum Torque Inch Pounds Continuous Load	Hand Operation
K-1-C	350	2,000
K-2-A	350	5,000
L6S Series L6N Series	400	2,000

	Recommended Torque Rating, Inch Pounds	Needle Bearings
L10S Series	650	Optional
1FR Series	1,080	"
L14S Series	1,230	"
3DR Series	1,800	"
L16S Series	2,200	"
35N Series	10,000	"

N Series	Recommended Torque Rating, Inch Pounds	Balanced for
45N	14,000	3600 R.P.M. Max.
5N	20,000	"
50N	20,000	"
6N	38,000	"
60N	38,000	"
7N	57,000	"
70N	57,000	"
75N	70,000	"

BW Series	Maximum Torque Inch Pounds Continuous Load	Momentary Load
BW-12	1,020	4,450
BW-1	1,695	7,500
BW-2	3,350	11,720
BW-3	4,450	16,800
BW-4	5,080	22,900
BW-5	8,640	34,200
BW-6	11,620	60,000
BW-7	28,600	150,000
BW-9	89,300	500,000

*Extra shock-load capacity built into all sizes.

Need a moderately small universal joint on your next project — for a hand-operated control rod, for example? Blood Brothers has it! In fact, you can select from any of four Series — all widely used on farm implements, road and construction machinery, tractor steering assemblies, etc.

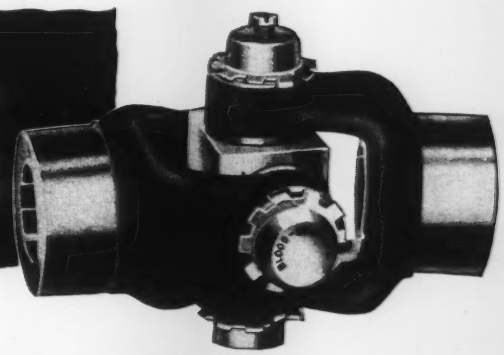
Or do you need a source for high speed joints and propeller shaft assemblies for trucks, busses or other mobile equipment? Blood Brothers builds a wide selection of automotive assemblies with torque capacities to 70,000 inch pounds.

For really heavy work, look at the BW Series — for transmitting up to 1,400 H.P. with momentary loads reaching 500,000 torque inch pounds! It's the largest commercial universal joint made — and Blood Brothers makes it.

Thus, when you specify Blood Brothers, you can select from a wide range of torque capacities . . . and be confident of top-quality universals that contribute dependability and smoothness to your product's performance.

For details, contact Blood Brothers, stating your specific problem. We'll be glad to cooperate with engineering suggestions.

TO this



UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

BLOOD BROTHERS machine division

Rockwell Spring and Axle Company

ALLEGAN, MICHIGAN

FURNAS ELECTRIC

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- Many New Control Items Listed.

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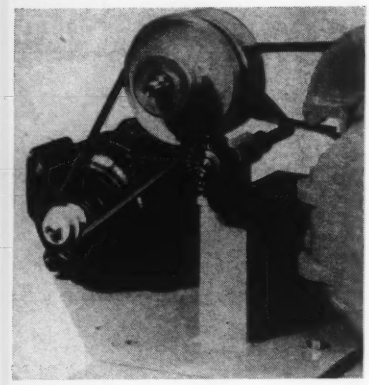
with the right control for the job. Now with in-between sizes in the magnetic starter line, you buy and pay only for the capacity you need.

The new catalog includes drum controllers designed for your requirements. These durable, economical controllers are for manual operation of reversing and multi-speed motors. Also time tested, dependable pressure switches for air compressors and water systems.

Write TODAY

for this new catalog to help you save money when buying Electric Motor Control. Furnas Electric Company, 1045 McKee St., Batavia, Ill.

FURNAS ELECTRIC
Batavia, Illinois



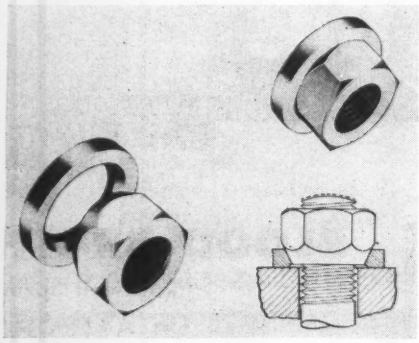
tween two fixed sheaves in this variable speed drive. The spring loaded belt face maintains correct belt tension in all speed positions, and full load carrying capacity is assured throughout the full speed range of 9 to 1. Unit uses standard V-belts in both the 4-in. ¾-hp and the 6-in. 1½-hp sizes. Hand control is located away from belts and moving parts. Made by **Speed Selector Inc.**, 118-U Noble Ct., Cleveland 13, O.

For more data circle MD-101, Page 175

Spring Locknut

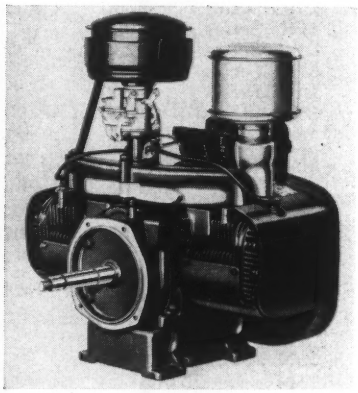
Hi-Load spring locknut consists of a nut with a conical lower end that mates with a hardened steel washer to form a single assembly. Hoop expansion of the washer by downward thrust of the nut results in a spring action which permits the nut to be deflected at a high spring load with relatively small deflection. Spring load is equivalent to the safe load of the bolt. Fastener attains designed load on the bolt without tightening by a torque wrench and maintains this load under a spring pressure so that any change in the bolted assembly is compensated for by the spring tension. Nut may be reused many times. Made by **Morse Products Development Co.**, 211 S. La Brea, Los Angeles, Calif.

For more data circle MD-102, Page 175



Heavy-Duty Engine

Designated K660P, this heavy-duty, two-cylinder opposed engine is a direct-mounting model which is available with three different mounting pads and a variety of power take-off shafts. Power output ranges from 26.8 hp at 3600 rpm to 15 hp at 1800 rpm. Gasoline powered and air-cooled, the engine



is 22½ in. long, 23⅛ in. wide and $27\frac{9}{16}$ in. high. Power take-off shafts are available in lengths to $6\frac{9}{16}$ in. Made by **Kohler Co.**, Kohler, Wis.

For more data circle MD-103, Page 175

Gasket Materials

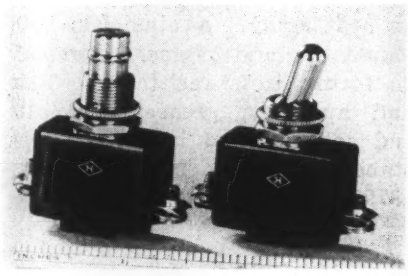
SE-370 and SE-380 silicone rubber compounds are claimed by General Electric Co. to exhibit the lowest compression set of all known elastomers, over a wide temperature range to 500 F. Harder than the company's similar SE-360 compound, the new materials provide stiffer stocks more suitable for sealing and gasketing applications involving high pressures. Other characteristics include low shrinkage and low moisture absorption. Applications include capacitor and transformer bushings; O-rings, gaskets and seals for aircraft engines; and gaskets for rail-

road, tractor and automobile engines. Made by Silicone Products Dept., **General Electric Co.**, Waterbury, N. Y.

For more data circle MD-104, Page 175

Small Switches

Diamond H series 1400 switches, measuring 61/64 x 21/32 x 1 3/16 in., are available with ratings to 1½ hp at 120 v, 2 hp at 240 v and to 25 amp at 120 and 240 v ac. Special ratings to 30 amp can be had. Switches may be equipped with dummy spade or screw terminals. Positive action results

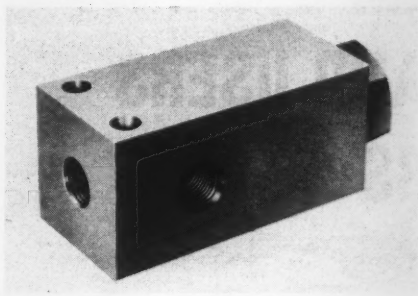


from actuating a pivoted rocking arm with a spring-loaded, abrasion resistant and insulated roller to keep the contact mechanism under pressure in all positions and also provide a wiping action at both make and break. Toggle switches are available in single-pole, single-throw and single-pole, double-throw types, the latter in both two and three-position models as well as momentary on one or both sides. Pushbutton types are single-pole, off and on, and are also available momentary double-throw, no off. Screw, solder tab and pigtail terminals are standard. All standard mounting arrangements are available with sleeve lengths from 11/32 to 15/32-in. Made by **Hart Mfg. Co.**, 110 Bartholomew Ave., Hartford, Conn.

For more data circle MD-105, Page 175

Flow Regulator

Combination by-pass and restrictor type, pressure compensated and nonadjustable flow regulator maintains a constant flow when pump

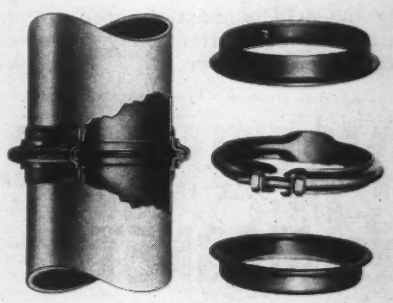


output varies or is greater than required for part or all of the system. Regulators used in series provide additional regulated circuits from one pump or power source. Restrictive characteristic of regulator prevents overspeeding of the controlled circuit when pressure at the by-pass port is high; by-pass characteristic allows the pump to operate at the pressure required in controlled circuit rather than continuously spill over a relief valve. Made with hardened and ground sliding valves and hardened and honed sleeves, regulators are available with ¼ and ⅜-in. pipe size for 3000 psi service. Range of regulated flow settings is ¼ to 6 gpm. Flow is only slightly affected by pressure, temperature or oil viscosity and will not vary more than ±5 per cent as long as the fluid specifications are not materially changed. Made by **Fluid Controls Inc.**, 1284 N. Center St., Mentor, O.

For more data circle MD-106, Page 175

Tubing Joint

Quickly assembled joint for 1 to 5-in. OD tubing is available in either stainless or cold-rolled steel. It is designed for coupling exhaust manifolds and exhaust piping joints, operating at normal inter-



What does "S. B." mean to you?

To some, it means "Soap Box" . . . the proverbial platform for platitudes. But, to thousands of designers and manufacturers, it means "Small Balls" by Universal, assuring true roundness and accuracy, so often despaired of in anything so microscopic.

Naturally, we make the larger balls, too, but we hope you'll get to know us through our Small Balls . . . a Sure Bet all around. Give us a chance to tell the Universal story.

Universal Ball co.
WILLOW GROVE
MONTGOMERY CO., PA.

BIG NEWS FROM STEARNS FOR MAKERS AND USERS OF FHP MOTORS

Now! For the first time—
Magnetic disc brakes for motors from 1/20 to 1/3 HP.

Stearns now offers you a line of magnetic disc brakes to meet the new NEMA frame standards in a horsepower range never before covered with this type of brake — the 1/20 hp. to 1/3 hp. range. Design engineers can now utilize the advantages of a spring-set, magnetically released brake in an entirely new field of motor applications.

This new *40 Series magnetic brake** is only 5 in. in diameter, less than 3-1/2 in. long, and has a torque range of from 6 lb. in. to 1 lb. ft. It is designed for mounting on the standard NEMA C end bell for motor frames 42-C and 48-C and is also available for floor mounting independent of motor. The brake incorporates all the design advantages which have made Stearns the preferred brake by the nation's leading motor manufacturers.

New! Magnetic disc brakes for re-rated motors—1/6 to 2 HP.

Stearns is also the first to offer the new *50 Series magnetic brake** for re-rated NEMA frames in the 1/6 hp. through 2 hp. motor range. It is available in four torque ratings: 1-1/2, 3, 6 and 9 lb. ft. This brake is designed to mount on new fractional hp. motor frames 56-C and 66-C and integral hp. motor frames 182 and 184. *It takes less than one-half the space previously required.*

Get all the facts about these new Stearns brakes that are broadening the field of magnetic disc brake applications. Write today for new descriptive literature.

1074

*Patent No. 2620901 12-9-52

MAGNETIC EQUIPMENT FOR ALL INDUSTRY

STEARNS MAGNETS

STEARNS MAGNETIC, INC. 692 S. 28 St., Milwaukee 46, Wis.

New Parts

nal combustion engine temperatures and low internal static pressures and for other similar applications. Joint is designated J-61 in all stainless steel and J-62 in cold-rolled steel. A special model, J-41, is available for use with stainless steel tubing. Made by **Marman Products Co. Inc.**, 11214 Exposition Blvd., Los Angeles 64, Calif.

For more data circle MD-107, Page 175

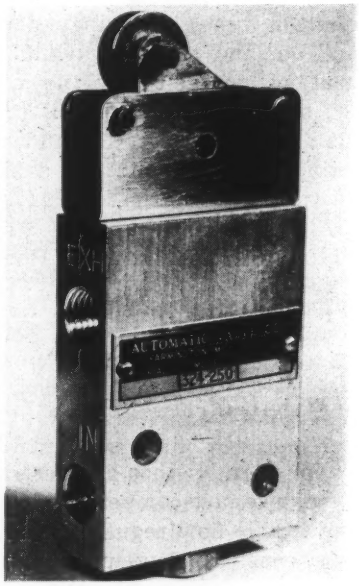
Phenolic Plastic Finish

Logo Force P-85 finish for phenolic plastic exhibits good hardness and adhesion characteristics without embrittlement even on heat aging. Available in both pigmented and pigmented metallic forms, it is resistant to heat and humidity, grease, chemicals and solvents and has good light stability. Made by **Logo Inc.**, 13799 S. Ave. "O", Chicago 33, Ill.

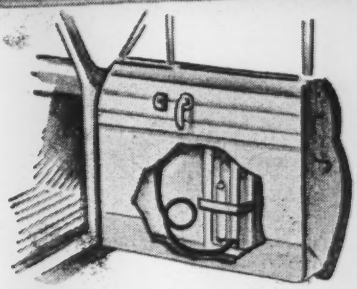
For more data circle MD-108, Page 175

Aluminum Pilot Valves

Series of manually operated, three-way pilot valves, for the operation of single-acting or spring-return cylinders and large master valves, is made in five models. Actuated by lever, roller cam, stud or 1 or 2-in. palm buttons, each model is available



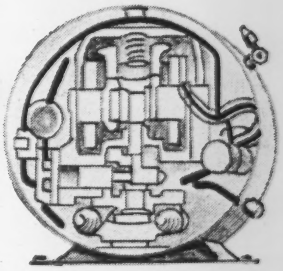
FROM *the Bundy Sketchbook*
TO *jog a designer's imagination*



AUTOMOTIVE HYDRAULIC WINDOW LIFT LINES

FRAME FOR OCCASIONAL TABLE

REFRIGERATOR COMPRESSOR LINES



REMARKS Do you have a tubing design that won't jell -- or a fabrication kink you can't untangle? Whatever your tubing headache, why not turn it over to our engineering experts. They offer you years of problem-solving experience, plus the added bonus of Bundyweld, the only tubing double-walled from a single strip (see below).

WRITE today for catalog or for help in developing your tubing ideas.

BUNDY TUBING COMPANY
DETROIT 14, MICHIGAN

SUPERMARKET PUSHCART FRAME

WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness,

and passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

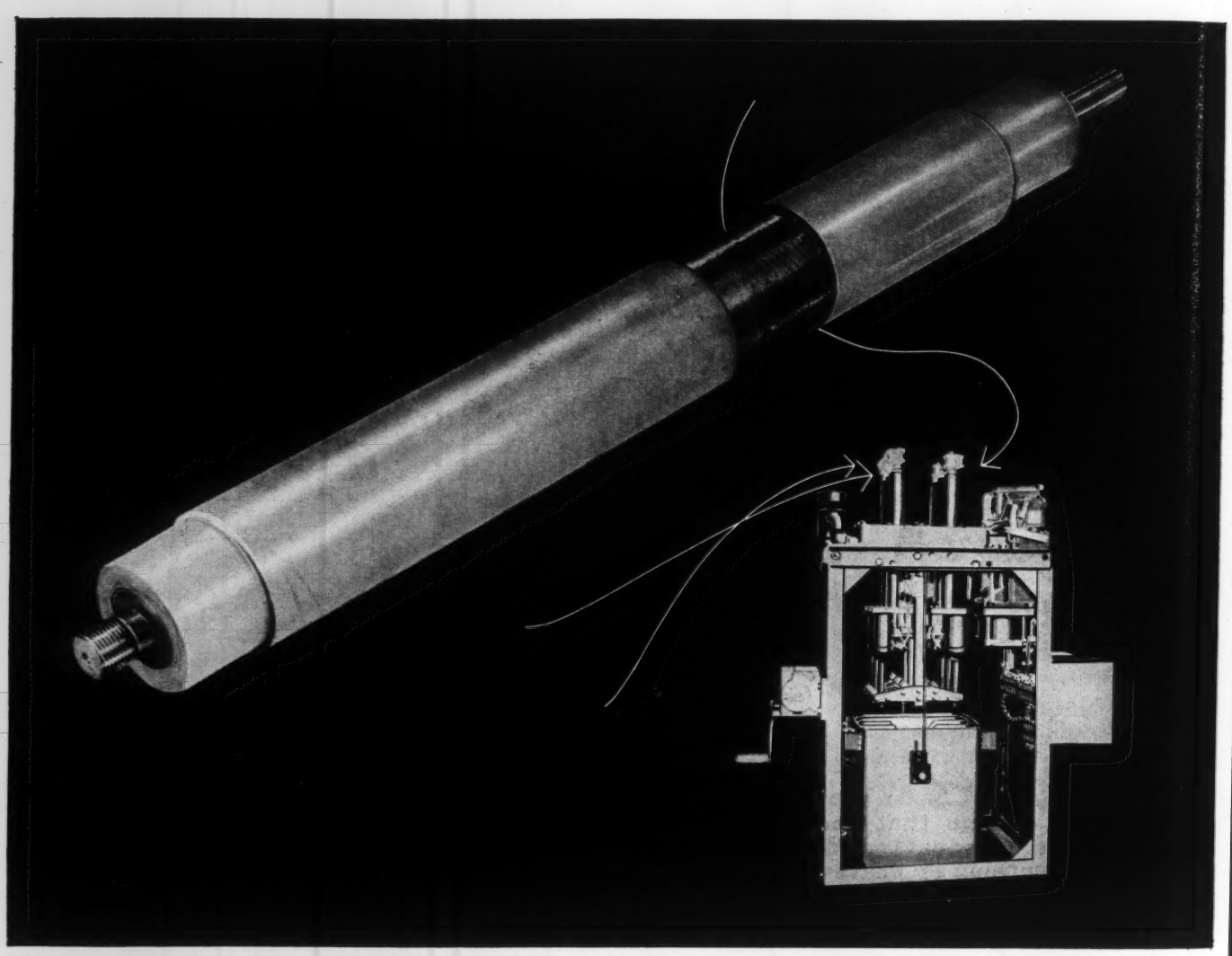
BUNDYWELD TUBING®

DOUBLE-WALLED FROM A SINGLE STRIP

Leakproof	Lightweight
High thermal conductivity	Machines easily
High bursting point	Takes plastic coating
High endurance limit	Takes plating
Extra-strong	Bright and clean
Shock-resistant	No inside bead
Ductile	Uniform I.D., O.D.

Bundy Tubing Distributors and Representatives: *Bridgeport, Conn.:* Korhumel Steel & Aluminum Co., 117 E. Washington St. • *Cambridge 42, Mass.:* Austin-Hastings Co., Inc., 226 Binney St. *Chattanooga 2, Tenn.:* Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • *Chicago 32, Ill.:* Lapham-Hickey Co., 3333 W. 47th Place • *Elizabeth, New Jersey:* A. B. Murray Co., Inc., Post Office Box 476 • *Los Angeles 58, Calif.:* Tubesales, 5400 Alcoa Ave. • *Philadelphia 3, Penn.:* Rutan & Co., 1717 Sansom St. • *San Francisco 10, Calif.:* Pacific Metals Co., Ltd., 3100 19th St. • *Seattle 4, Wash.:* Eagle Metals Co., 4755 First Ave., South • *Toronto 5, Ontario, Canada:* Alloy Metal Sales, Ltd., 181 Fleet St., E.

Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.



Where two materials are better than one

Properties of Synthane

Among the outstanding properties of *Synthane* are:

1. Mechanical strength. Synthane exhibits excellent strength under tension, compression, impact, vibration and mild shock loads. It will not delaminate.

2. Dielectric strength. Synthane is widely used as an insulating material in many different applications.

3. Low moisture absorption. Most grades of Synthane are highly moisture resistant. Special grades are available for applications where absorption must be at a minimum.

4. Dimensionally stable. Synthane is a thermosetting plastic with a minimum cold flow. It holds its shape under normal conditions and at elevated temperatures.

5. Availability. In addition to more than 33 grades of sheets, Synthane is also supplied in many grades of rods and tubes. Molded-laminated and molded-macerated parts are also manufactured. A complete fabricating service is available.

● This circuit breaker bushing is a most unusual application for *Synthane* laminated plastics combined with another material. Basically it's a conductor and an insulator—a solid copper bar—to which is bonded a thick insulating shield of *Synthane* laminated plastic.

There is one little joker in the design: each bushing contains a thin copper grid, only .003" thick, buried in the insulating plastic. It is positioned concentric to the copper core as the *Synthane* is being wound before curing. After curing, the bushing goes to our fabricating department. Here precision machinists turn off the *Synthane* over the grid until the delicate grid is fully exposed—yet unharmed.

Synthane—the material—was chosen for this job because of its combination of high dielectric strength, toughness and machinability. *Synthane*, the company, was selected because of its ability to handle a tough job. Our fabricating department is especially equipped to work with laminated plastics.

Look into the advantages of *Synthane* laminated plastics and *Synthane* fabricating service. Write for a free catalog detailing both. Synthane Corporation, 5 River Road, Oaks, Pennsylvania.

Our 25th Year

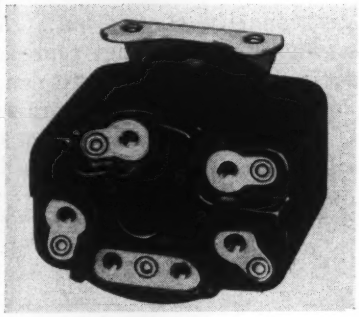
SYNTHANE CORPORATION, OAKS, PA.

SYNTHANE
LAMINATED S PLASTICS

normally closed or normally open. These small, compact valves are used at standard pressures for controlling flow of compressed air and are also available for low-pressure hydraulic operation. Made by **Automatic Valve Co.,** 37415 Grand River, Farmington, Mich.

For more data circle MD-109, Page 175

Motor Starting Relays



Totally enclosed potential motor starting relays are used to start single-phase capacitor type motors in applications where use of a centrifugal switch is impractical or impossible. Snap-action mechanism ensures positive contact action under normal operation. Relays may be mounted in any position, have readily accessible wiring terminals and are available with extra single and double dummy terminals. General purpose shunt version is available with single-pole, normally open; single-pole, normally closed; or single-pole, double-throw contacts. Maximum coil inrush is 12 va, or 10 va sealed. Approximate size is 1 23/32 in. wide, 2 1/16 in. long, 1 51/64 in. high. Made by R-B-M Mfg. Div., **Essex Wire Corp.,** Hanna St., Logansport, Ind.

For more data circle MD-110, Page 175

Protective Coatings

Five new Iridite coatings are available for nonferrous metals. No. 4-73 and No. 4-75 Cast-Zinc-Brite coatings provide a bright decorative and protective finish directly on zinc diecastings. A luster is provided by the chemical polishing action of the solution. No. 18-P Silver-Kote provides tarnish resistance for industrial silver plate with minimum effect on electrical characteristics and solderability and without substantially changing the appearance of the silver. Coating No. 17-P, Cupreous-Kote, provides corrosion resistance and paint adherence for copper and copper alloy surfaces. It can be dyed yellow, red, orange or green for color identification purposes. No. 14-2 Al-Coat aluminum finish can produce a finish ranging in appearance from yellow-iridescent to a uniform deep brown or can be bleached to produce a clear protective film. All finishes are applied by dipping. Made by **Allied Research Products Inc.,** 4004-06 E. Monument St., Baltimore 5, Md.

For more data circle MD-111, Page 175

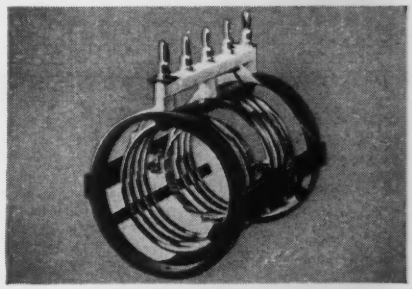
Servo Motor

Type M-100 low-inertia servo motor has a new lamination design for high performance. Built in 1.75-in. OD size, it has a hermetically sealed stator for high operating stability and high torque-to-inertia ratio for rapid acceleration and deceleration service. Inoperative under single phase conditions, it has a sloping speed-torque characteristic which provides viscous damping in control applications. Motor operates on 115 v, two-phase, 400 cycle ac. No-load speed is 10,000 rpm; stalled torque, 2.7 oz-in. Motor weighs 12.2 oz. Made by **Infra Electronic Corp.,** 553 Eagle Rock Ave., Roseland, N. J.

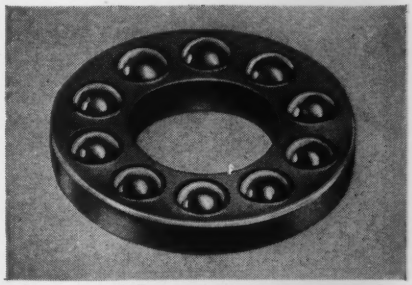
For more data circle MD-112, Page 175

SYNTHANE

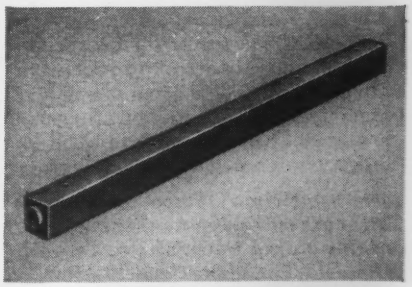
laminated plastics at work



In broadcasting This air inductor coil is used in radio and television broadcasting. Its Synthane end rings act as insulators, strong supports.



In machinery Synthane ball bearing retainers are standard in many different types and brands of ball bearings. Synthane is mechanically strong, almost friction-free, light in weight.



In plating equipment
Plating barrel parts are made of Synthane because of its combination of properties. It's machinable, resistant to acids and alkalis, and it has high dielectric strength.

What's your PROBLEM?
MAIL COUPON FOR FREE FOLDER

Our 25th Year
SYNTHANE CORPORATION
5 River Road, Oaks, Pa.
Please send me your free folder describing advantages, properties, uses, and kinds of Synthane plastics.
Name_____
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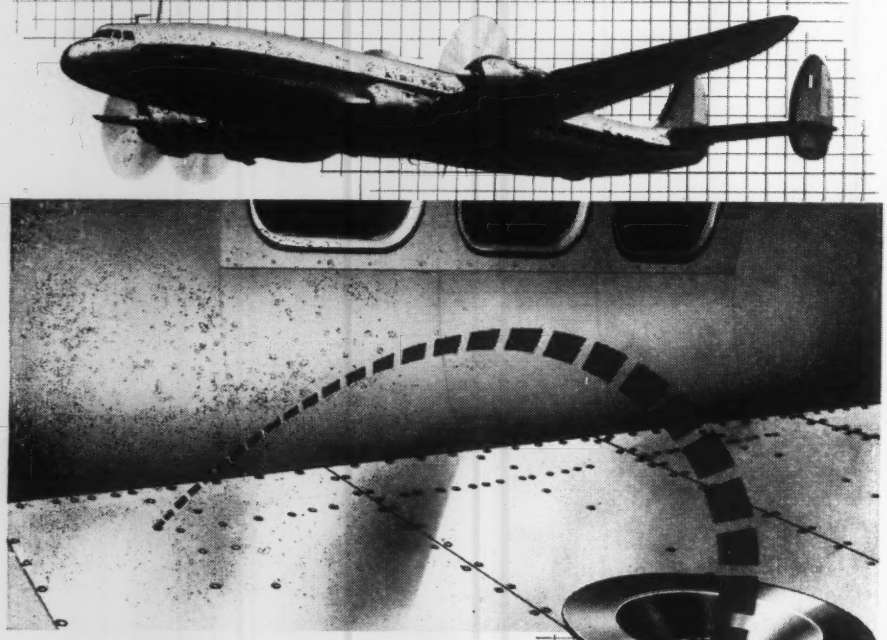
2nd of a Series

...another

CRITICAL FASTENING PROBLEM

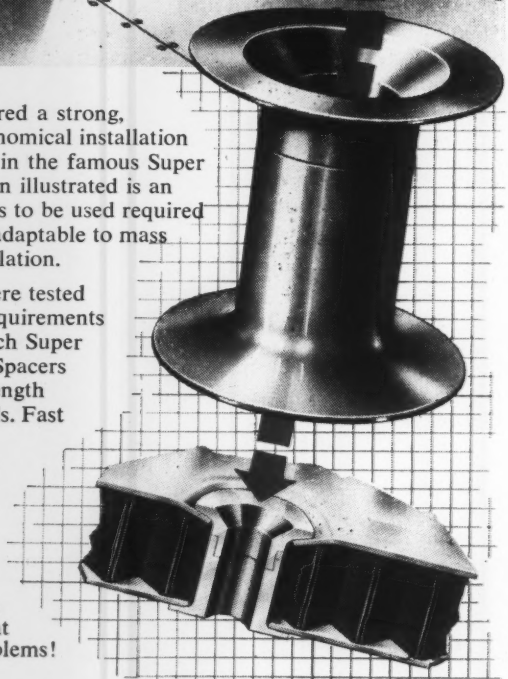
solved by Delron



problem: Lockheed engineers required a strong, lightweight bolt spacer for fast, economical installation of aluminum honeycomb structure in the famous Super Constellation. The floor construction illustrated is an example. Large quantity of fasteners to be used required low weight per unit, and had to be adaptable to mass production as well as manual installation.

solution: Delron's Fasco Spacers were tested by Lockheed and more than met requirements of this critical fastening job. On each Super Constellation, approximately 3500 Spacers are used, providing high column strength with a total weight of only 12 pounds. Fast 200 per hour mechanical sub-assembly installation as well as hand assembly, if required, are the reasons Fasco Spacers make ideal fasteners for honeycomb type structure.

This is another example of Delron's long service and design experience at work—solving critical fastening problems!



WHAT IS YOUR CRITICAL FASTENING PROBLEM?

Clip this ad to your letterhead, and mail for product data on items checked: MD-2

- ☐ Sandwich structure fastening
- ☐ Fasteners to 1200°F. operation
- ☐ Fasteners to 1600°F. operation

Name_____

THE DELRON COMPANY, INC.

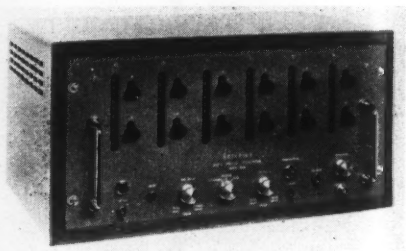
5224 Southern Avenue, South Gate, California

ENGINEERING DEPARTMENT

EQUIPMENT

Preset Counter

Series 5440 dual preset counter provides output information at any two counts within the maximum capacity of the unit. Any discrete physical change represented by a changing voltage can be counted. Various transducers such as photocells, magnetic pickups, switches or other devices that provide a suitable voltage output are used to operate the counter. The



physical change may occur at rates between dc and 40,000 times per second, the maximum continuous counting rate of the preset decimal counting units. Presetting the counter is accomplished by rotating the two switches adjacent to each decade. Made by Berkeley Div., **Beckman Instruments Inc.**, 2200 Wright Ave., Richmond, Calif.

For more data circle MD-113, Page 175

Oscillograph

For high-quality dynamic recording measurement, this 26-trace type 5-114 recording oscillograph has an accurate 0.45 to 115 in. per second record speed range and provides records of phenomena from static conditions to 3000 cycles per second. Positive, gear type record drive system uses no belts or friction drives. Speed can be changed easily without tools. Timing lines photographed simultaneously with

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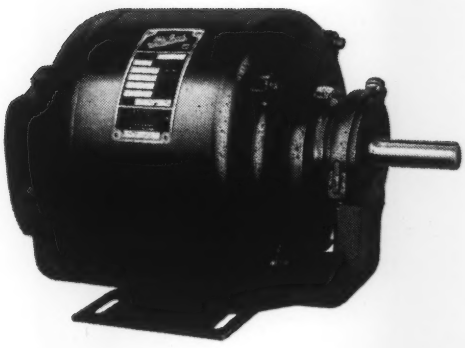

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RUGGED FRACTIONAL HORSEPOWER APPLIANCE MOTORS

is a *satisfied customer!* And one way to assure satisfied customers is to standardize on Packard electric motors for your electrical appliances.

The motors built by Packard Electric have been well and favorably known for 37 years. There is no better fractional horsepower electric motor on the market. So, when you specify Packard electric motors, you benefit in two ways: Your product will give your customers reliable and long-lasting performance; the satisfaction experienced by your customers will be reflected in greater acceptance for your product.

GM GENERAL MOTORS

Packard

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TRADE MARK

Packard Electric Division
General Motors Corporation,
Warren, Ohio

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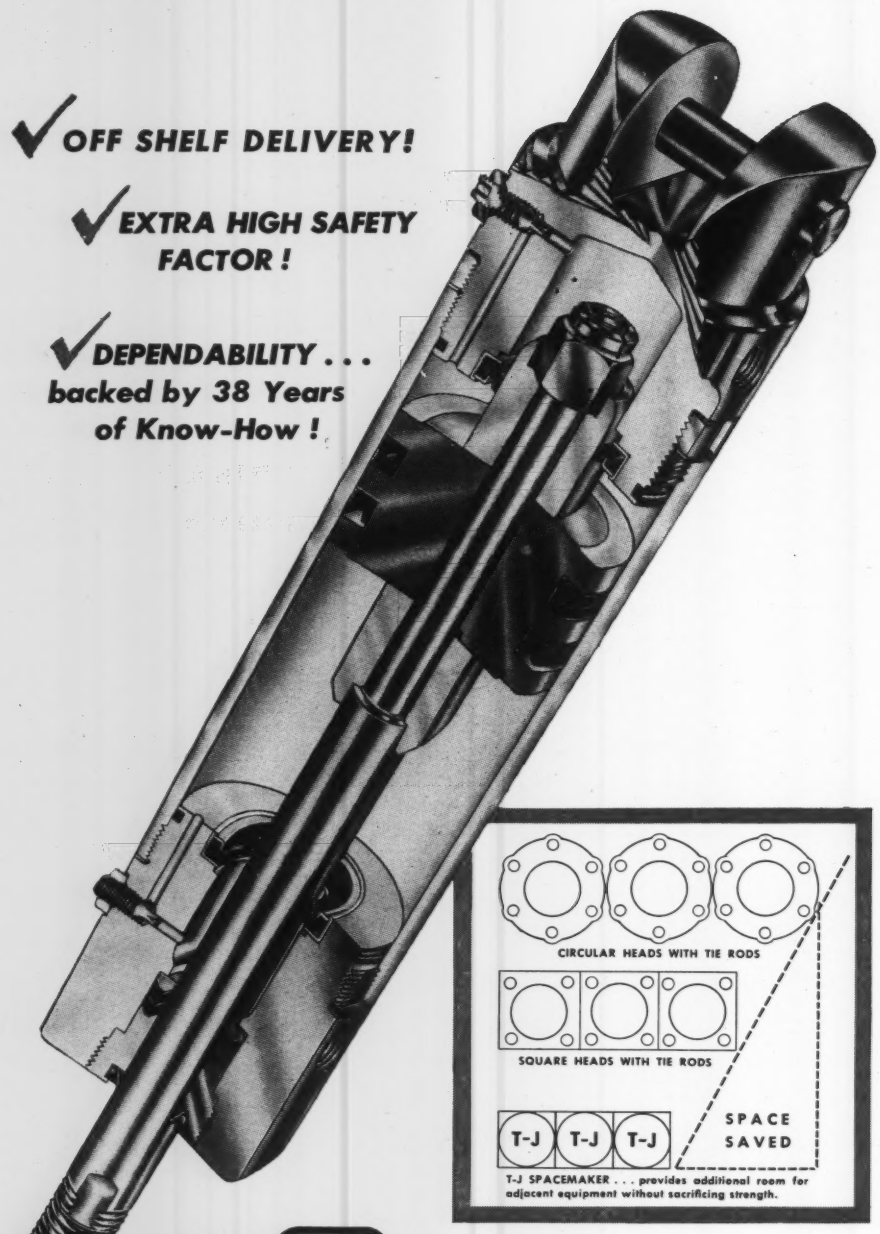
✓EXTRA HIGH SAFETY FACTOR!

✓DEPENDABILITY . . . backed by 38 Years of Know-How!



NEW T-J

Spacemaker

AIR CYLINDERS

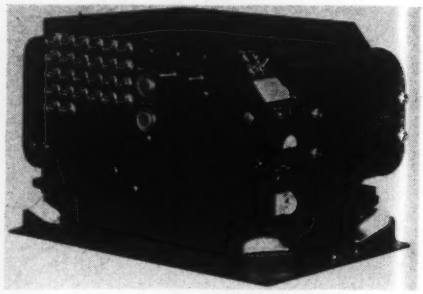
Streamlined design of the new T-J Spacemaker *eliminates tie rods . . . saves up to 40% in mounting space!* It's performance-proved . . . *super rugged* with extra high safety factor . . . solid steel heads . . . heavy wall, precision honed, *hard chrome plated,* seamless steel body . . . leakproof cylinder head to body construction . . . heavy duty, hi-tensile, *hard chrome plated* piston rod.

Available with the new T-J Super Cushion Flexible Seals which insure positive cushion with automatic valve action for fast return stroke. Many standard sizes and styles . . . for pushing, pulling, lifting, clamping or control jobs. T-J dependability. Write for bulletin 454. The Tomkins-Johnson Co., Jackson, Mich.

T-J TOMKINS-JOHNSON

RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

Engineering Equipment

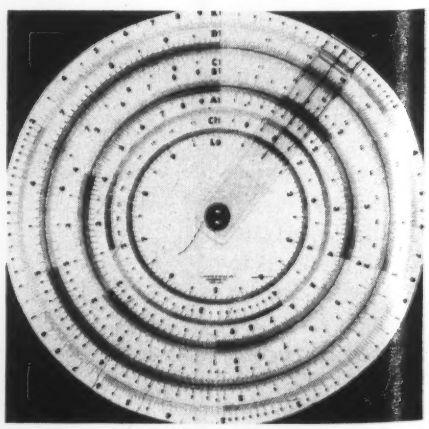


the data provide positive time correlation at 0.1 and 0.01-second, or at 0.1-second intervals only. Unit is equipped with a detachable 125-ft record magazine, unexposed-footage indicator, "no record" warning devices, record length selector, heated magnet block and individual galvanometer-input connectors. Glareless viewing screen and scanning system permit visual check of waveforms with frequencies of 0 to 500 cycles per second and facilitate initial vertical and lateral galvanometer adjustments. Accessories are available to increase unit's scope of application. Overall dimensions of dc model are 12¾ x 12½ x 20¾ in.; weight is 85 lb. Ac model is 2⅞ in. longer, weighs 96 lb. Made by **Consolidated Engineering Corp.,** 300 N. Sierra Madre Villa, Pasadena 15, Calif.

For more data circle MD-114, Page 175

Circular Slide Rule

This 8-in. diameter circular slide rule made of dimensionally stable Vinylite plastic is equivalent to a 20-in. straight slide rule. It performs functions of multiplication, division, proportions, find-



J&L's New JALTEN series enables you to select low-alloy, high-strength steel in the following combinations of advantages:

High strength, good formability and fabricating —good resistance to low temperature impact.

High strength, moderate forming—improved resistance to atmospheric corrosion.

High strength—improved resistance to abrasion.

Remember to specify JALTEN High Tensile Steel for

- **HIGH STRENGTH • RESISTANCE TO CORROSION**
- **GOOD FORMABILITY • RESISTANCE TO ABRASION**

J&L STEEL

Jones & Laughlin
STEEL CORPORATION — *Pittsburgh*

Jones & Laughlin Steel Corporation
Dept. 410, 3 Gateway Center, Pittsburgh 30, Pa.

Please forward a copy of your booklet, Jalten low-alloy, high-strength steel.

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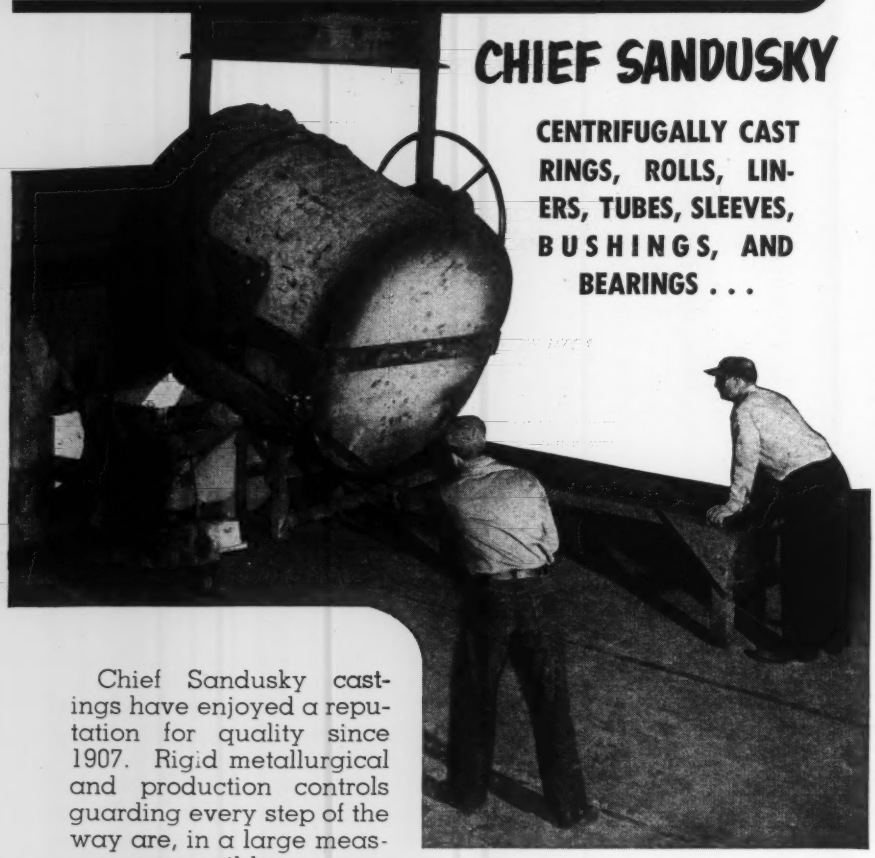
a Big Pour UNDER RIGID METALLURGICAL AND PRODUCTION CONTROLS

CHIEF SANDUSKY

CENTRIFUGALLY CAST RINGS, ROLLS, LINERS, TUBES, SLEEVES, BUSHINGS, AND BEARINGS . . .



Chief Sandusky castings have enjoyed a reputation for quality since 1907. Rigid metallurgical and production controls guarding every step of the way are, in a large measure, responsible.

Accidents may be lucky or not. But neither kind has any place in the making of highly specialized cylindrical castings.

From initial laboratory analyses through exacting production steps to delivery of the finished product, Chief Sandusky castings have been watched over by very particular experts—equipped with eagle eyes.

The makers of Chief Sandusky castings know that to hold the position of leadership they have earned, they must constantly search out improvements, develop better methods, and adhere to standards of highest quality.

This is all to the advantage of users . . . who agree that the best in cylindrical castings bear the name, *"Chief Sandusky."*

C. M. LOVSTED & CO., SEATTLE, WASH. • TYNE BROS., BIRMINGHAM, ALA. • CORDES BROS., SAN FRANCISCO AND LONG BEACH, CALIF.

SANDUSKY FOUNDRY and MACHINE CO.

615 W. Market Street Sandusky, Ohio

Engineering Equipment

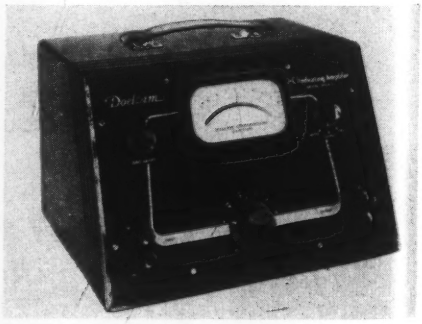
ing squares or square roots and cubes or cube roots and computing reciprocals and logarithms. Sliding disks are 7½ and 8 in. diameter with graduations impressed in blue and black and protected by clear over-lamination. Instructions for use are printed on reverse side. Made by **Allegheny Plastics Inc.,** 52 Thorn Run Rd., Coraopolis, Pa.

For more data circle MD-115, Page 175

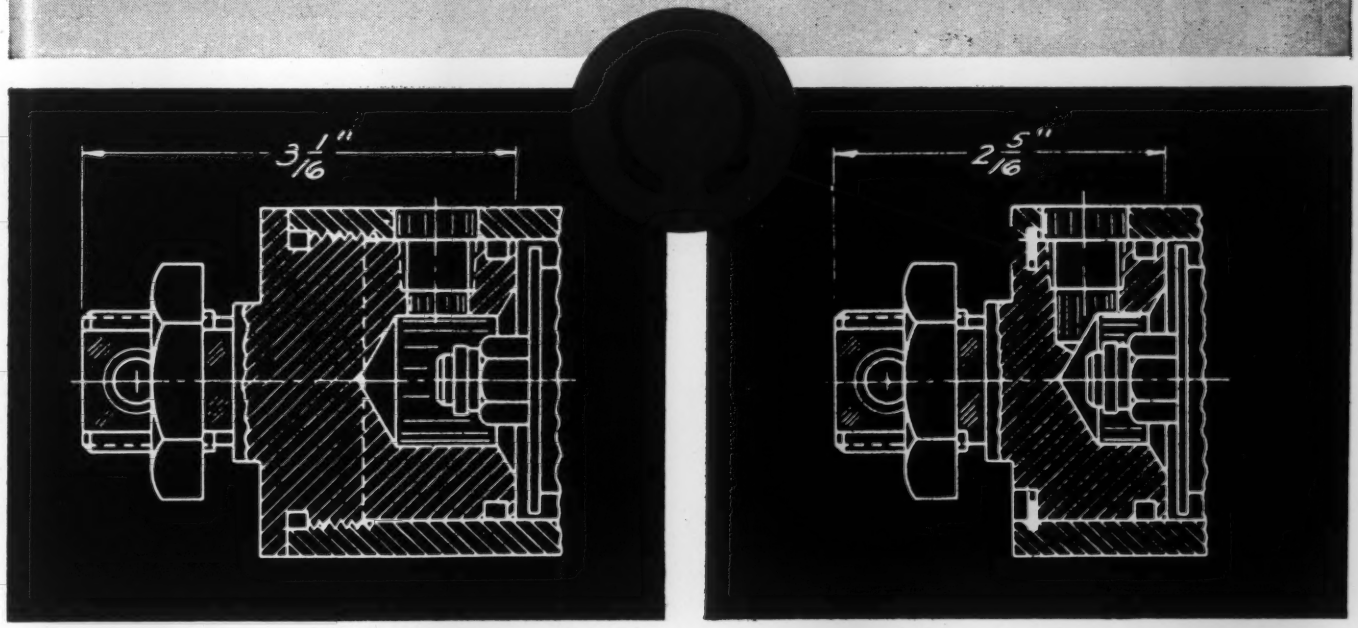
DC Indicating Amplifier

For use wherever a minute electrical signal must be measured, amplified or recorded, model 2HLA-3 dc indicating amplifier can measure signals as low as 2×10^{-15} watt. In the first of four stages of operation, the dc input signal is changed to an ac signal by means of a second-harmonic magnetic converter. This converter has no moving parts and is insensitive to changes in ambient temperature. In the second stage a very high gain voltage amplifier magnifies the ac signal received from the converter. Demodulator in third stage then changes the amplified ac signal to dc. At the fourth stage a power amplifier greatly increases the power output to the meter on the face of the instrument or to the output terminals where sufficient power is supplied to drive an inking recorder or a control device. A self-contained power supply furnishes energy to the voltage amplifier, power amplifier and oscillator. Instrument operates on 105 to 125 v, 0.3 amp, 50 to 70 cycles per second. Size is 12 x 7¾ x 9¾ in.; weight 20 lb. Made by **Doelcam Corp.,** Soldiers Field Rd., Boston 35, Mass.

For more data circle MD-116, Page 175



Waldes Truarc Rings Cut Costs $3.26 per Unit, Reduce Size and Weight of Air Cylinder!



OLD STYLE air cylinder, with thread-secured head, required costly tapping, chasing and assembly operations. Also, satisfactory maintenance of packing unit necessitated use of pipe wrenches on painted surfaces.

NEW cylinder head is secured with precision-ground Waldes Truarc Rings. This produces perfect alignment of head within the housing, difficult to obtain with screw-thread seating. Maintenance is quick and easy.

WALDES TRUARC RINGS PERMITTED THESE SAVINGS

Production Time Cut..17 minutes
Weight Saved.....1¾ lb.
Length Shortened.....1½ inches
Cost Saved.....$3.26 unit

■ The A. K. Allen Company of Brooklyn, New York, maker of *AllenAir* cylinders, now uses two Waldes Truarc Inverted Rings (series 5008) to secure heads rigidly within tubes.

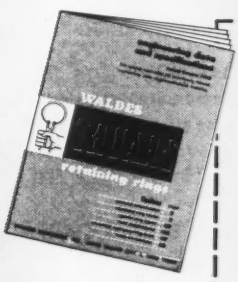
■ TRUARC Rings, in this application, are ground parallel by A. K. Allen to .001 tolerance. In a static hydraulic bursting test, the 3" unit (recommended for 350 p.s.i.) withstands a pressure of 2000 p.s.i. And at bursting-point, the brass groove gives way; the Truarc Ring remains intact.

■ Waldes Truarc Retaining Rings are precision-engineered . . . quick and easy to assemble and to disassemble. They can be used over and over again. There's a Waldes Truarc Ring to answer every fastening problem.

■ Find out what Waldes Truarc Retaining Rings can do for you. Send your blueprints to Waldes Truarc engineers.

For precision internal grooving and undercutting . . . Waldes Truarc Grooving Tool

SEND FOR NEW CATALOG



WALDES
TRUARC
REG. U. S. PAT. OFF.
RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS AND PLIERS ARE PROTECTED BY ONE OR MORE OF THE FOLLOWING U. S. PATENTS: 2,382,947; 2,382,948; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,509,081; AND OTHER PATENTS PENDING.

MD276

Waldes Kohinoor, Inc., 47-16 Austel Pl., L. I. C. 1, N. Y.

Please send me the new Waldes Truarc Retaining Ring catalog.

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Title .....

Company .....

Business Address.....

City..... *Zone*..... *State*.....

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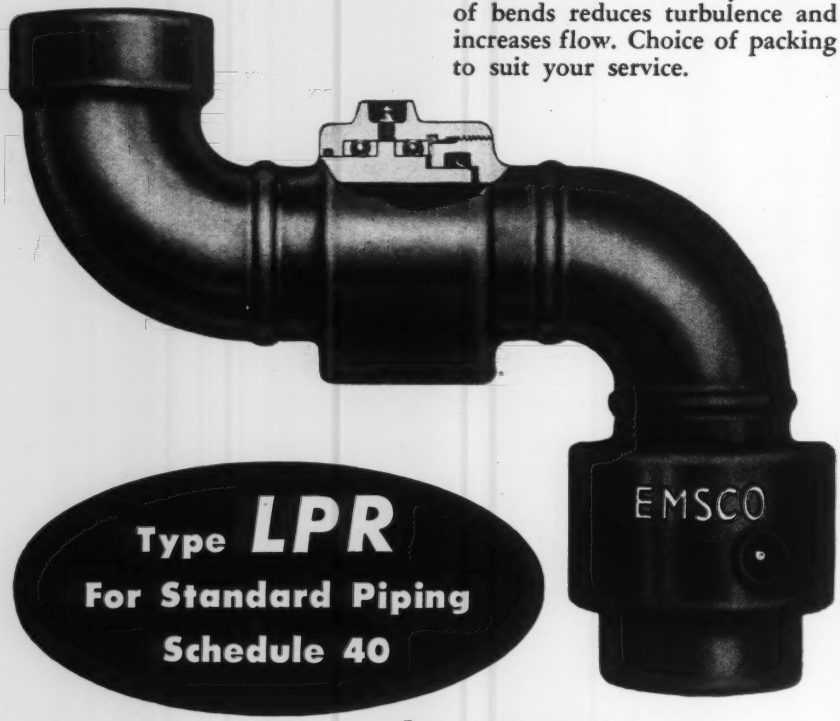
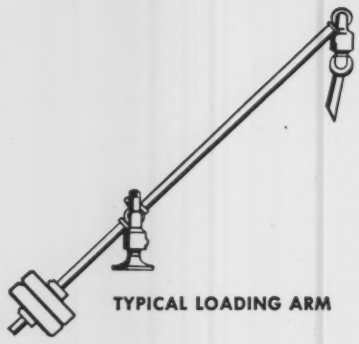


Type LPR
For Standard Piping
Schedule 40



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For liquids, semi-solids, gases, steams, etc.

2. FREE TURNING
Easy swiveling for full 360° in 1, 2 or 3 planes.
Balls rotate on formed alloy steel races.

3. FULL FLOW
Smooth bore, large easy bends.

4. CHOICE OF PACKING
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Recent Books

Magnetic-Amplifier Circuits. *By William A. Geyger, Magnetics Division, U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Md., 289 pages, 6 by 9 inches, clothbound; published by McGraw-Hill Book Co., New York; available from* MACHINE DESIGN, *$6.00 postpaid.*

Written for designers, this volume presents a practical treatment of the fundamental principles, characteristics and applications of magnetic-amplifier circuits. Extended mathematical considerations and cumbersome proofs are avoided. Descriptive and graphical methods are used to give a qualitative and quantitative interpretation of essential facts.

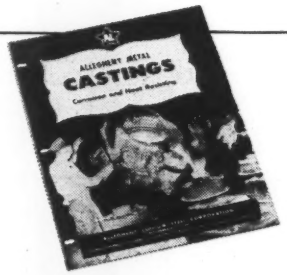
Chapter 1 gives a classification of saturable-core devices and reviews the history of magnetic amplifiers. Chapter 2 describes magnetic core materials, different kinds of core construction, winding arrangements and various types of rectifier devices, as used in magnetic-amplifier circuits. In chapters 3 to 16 the book presents a systematic description of the numerous types of magnetic-amplifier circuits. Chapters 17 and 18 discuss technical properties, transient response and typical applications of magnetic amplifiers, particularly those in instrumentation, servomechanisms, regulators, automatic control devices and electronic arrangements. References listed at the ends of chapters include important European patents.

♦

Elements of Mechanism. *By Venton Levy Doughtie, professor of mechanical engineering, University of Texas, and Walter H. James, professor emeritus of mechanical engineering, Massachusetts Institute of Technology; 502 pages, 5¼ by 8½ inches, clothbound; published by John Wiley & Sons Inc., New York; available*

"BIG"–"SPECIAL"–"TINY"–"INTRICATE"...

We can handle any job you have



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32 pages of valuable and complete data on stainless castings: analyses, properties, technical data on handling and heat treatment, typical applications, how to order, etc.

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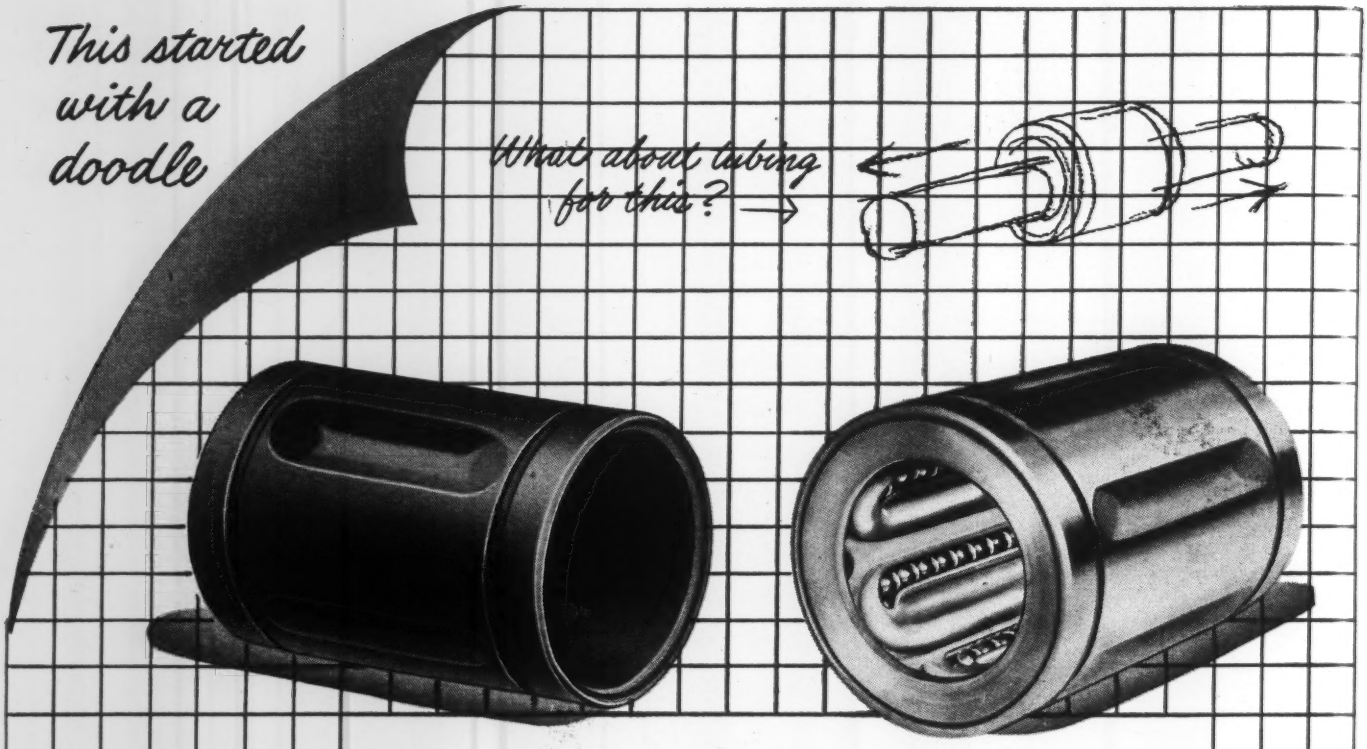
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Association Publications

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♦

Viscosity of Lubricants under Pressure. *By Mayo D. Hersey and Richard F. Hopkins for the ASME Research Committee on Lubrication; 87 pages, 8½ by 11 inches, paperbound; available from the American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y., $5.00 per copy.*

This booklet presents the results of a study conducted for the ASME Research Committee on Lubrication covering high pressure viscos-

(*Continued on Page* 228)

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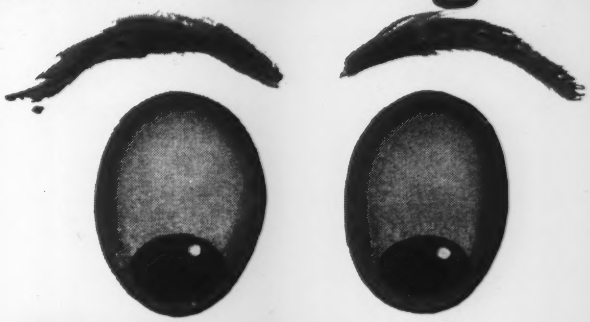

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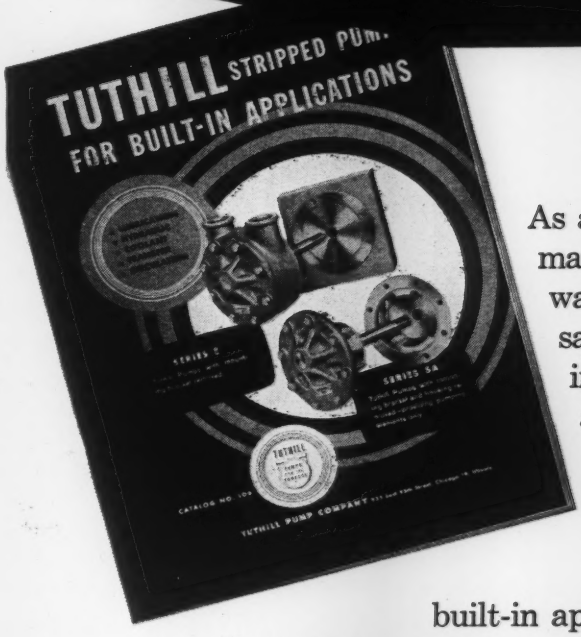

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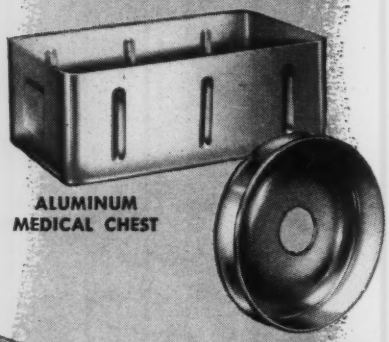

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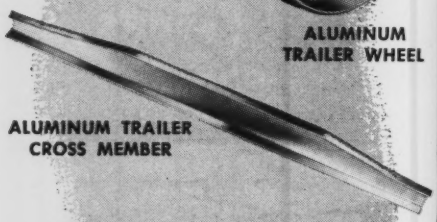

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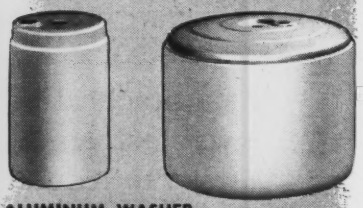

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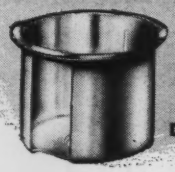

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Photograph shows 1700-ton hydraulic press in operation at a Reynolds plant. Work in progress is one of the largest drawn aluminum parts ever made—a one-piece 12′ x 4′8″ hull for an aluminum boat. This press is currently producing other drawn parts 6′ in diameter.

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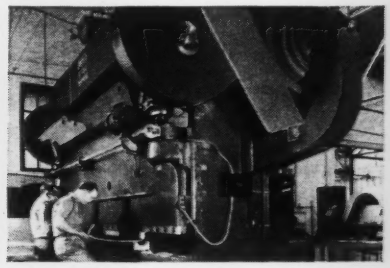

This 12', 300-ton press brake handles thick aluminum plate. Press brakes from 22½ tons are available for your requirements by Reynolds Aluminum Fabricating Service.

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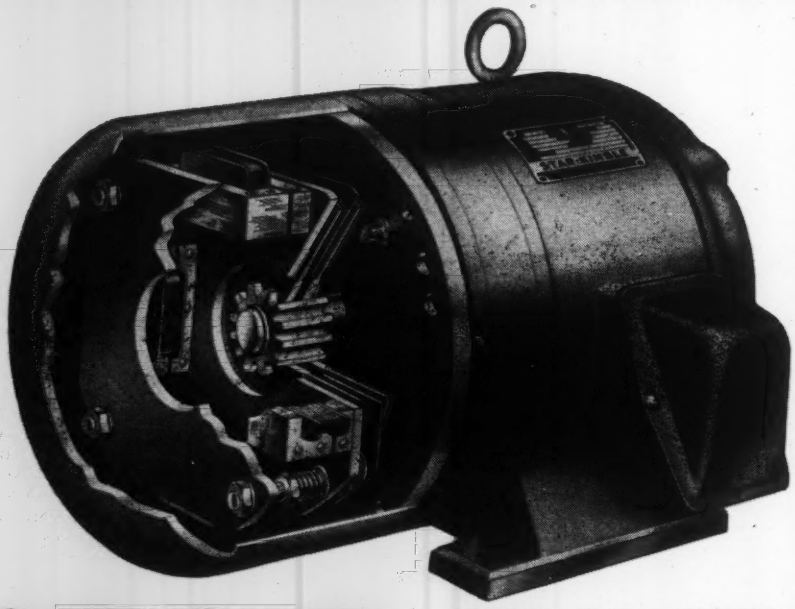

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The Engineer's Library

(*Continued from Page 225*)

ity. It includes a co-ordination of experimental data from 12 major investigations dealing with fatty oils, petroleum oils, compounded oils and other lubricants.

♦

Materials for Product Development —1953. *265 pages, 6 by 9 inches, clothbound; available from Clapp & Poliak, Inc., 341 Madison Ave., New York 17, N. Y., $7.50 per copy.*

This book is a compilation of the Proceedings of the Basic Materials Conference held in New York, June, 1953. It includes the talks on basic materials, along with questions and answers, presented at this conference.

New Standards

1953 Supplement to Book of ASTM Standards. *Seven volumes, 6 by 9 inches, paperbound; available from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.*

These supplements contain extensively revised standards and new and extensively revised tentatives in these materials fields that have been accepted since the appearance of the 1952 Book of ASTM Standards. The parts comprising the complete supplement set are:

Part 1—Ferrous Metals; 10 standards, 52 tentatives, 363 pages.

Part 2—Non-Ferrous Metals; 8 standards, 41 tentatives, 277 pages.

Part 3—Cement, Concrete, Ceramics, Thermal Insulation, Road Materials, Waterproofing, Soils; 17 standards, 45 tentatives, 383 pages.

Part 4—Paint, Naval Stores, Wood, Fire Tests, Sandwich Constructions, Building Constructions, Wax Polishes; 9 standards, 21 tentatives, 162 pages.

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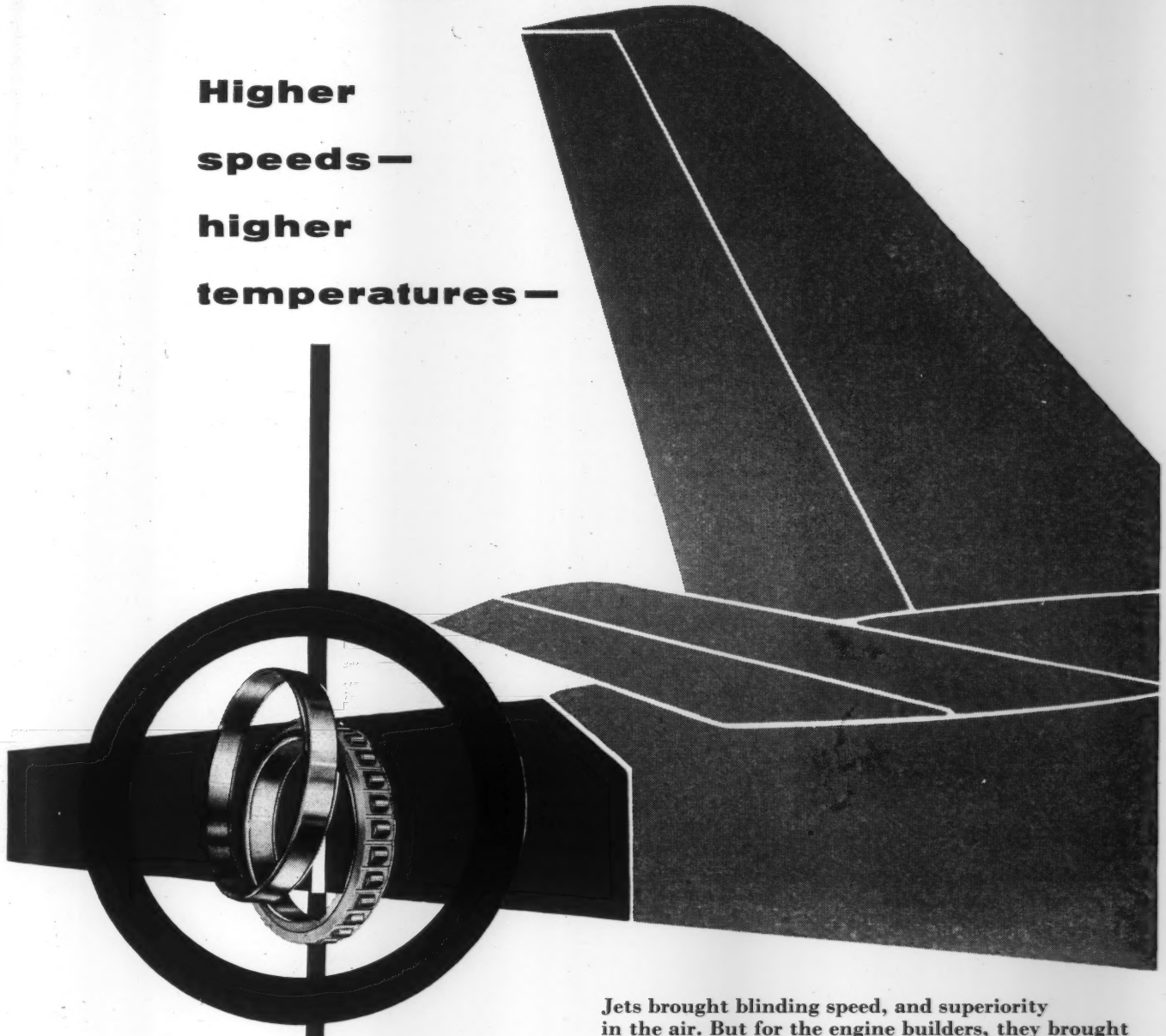

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Lockheed F-94A & B Air Force Fighter Plane
Lockheed TO-1 U.S. Navy Version of the F-80G For Use as Jet Trainer
Martin P4M-1 Long Range Navy Patrol Bomber
Martin B-57A U.S. Air Force Version of the English Electric Canberra Medium Bomber
North American AJ-1 "Savage" Navy Carrier Attack and Search Airplane
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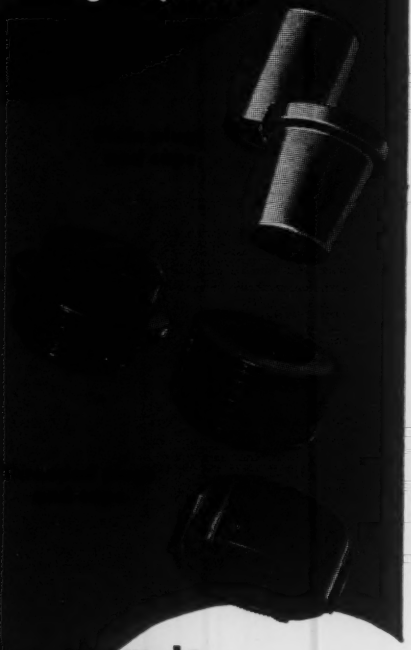

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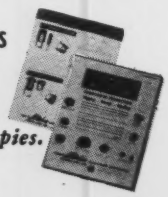

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trical Insulation; 4 standards, 24 tentatives, 195 pages.

Part 7—Textiles, Soap, Water, Paper, Adhesives, Shipping Containers; 7 standards, 39 tentatives, 295 pages.

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Preferred Ratings for Power Circuit Breakers. *ASA C37.6-1953; 6 pages, 8½ by 11 inches; paperbound; available from American Standards Association Inc., 70 East Forty-fifth St., New York 17, N. Y., 40 cents per copy.*

Dealing with alternating current power circuit breakers, this publication represents standard practices in this field for the United States. It contains three tables along with explanatory notes for indoor oil and oilless power circuit breakers, and outdoor power circuit breakers.

♦

ASTM Specifications and Tests for Electrodeposited Metallic Coatings, 99 *pages, 6 by 9 inches, paperbound; copies available from American Society for Testing Materials,* 1916 *Race St., Philadelphia 3, Pa.,* $1.85 *per copy.*

Publication contains the following standards:

A 164—53. Spec. for Electrodeposited Coatings of Zinc on Steel.

A 165—53. Spec. for Electrodeposited Coatings of Cadmium on Steel.

A 166—53 T. Spec. for Electrodeposited Coatings of Nickel and Chromium on Steel (Tentative).

A 219—51 T. Methods of Test for Local Thickness of Electrodeposited Coatings (Tentative).

B 117—49 T. Method of Salt Spray (Fog) Testing (Tentative).

B 141—45. Spec. for Electrodeposited Coatings of Nickel and Chromium on Copper and Copper-Base Alloys.

B 142—53. Spec. for Electrodeposited Coatings of Nickel and Chromium on Zinc and Zinc-Base Alloys.

B 177—49. Rec. Practice for Chromium Plating on Steel for Engineering Use.

B 183—49. Rec. Practice for Preparation of Low-Carbon Steel for Electroplating.

B 200—53 T. Spec. for Electrodeposited Coatings of Lead on Steel (Tentative).

B 201—49 T. Spec. for Chromate Finishes on Electrodeposited Zinc, Hot-Dipped Galvanized, and Zinc Die-Cast Surfaces (Tentative).

B 242—53. Rec. Practice for Preparation of High-Carbon Steel for Electroplating.

B 252—53. Rec. Practice for Preparation of Zinc-Base Die Castings for Electroplating.

B 253—53. Rec. Practice for Preparation of and Electroplating on Aluminum Alloys.

B 254—53. Rec. Practice for Preparation of and Electroplating on Stainless Steel.

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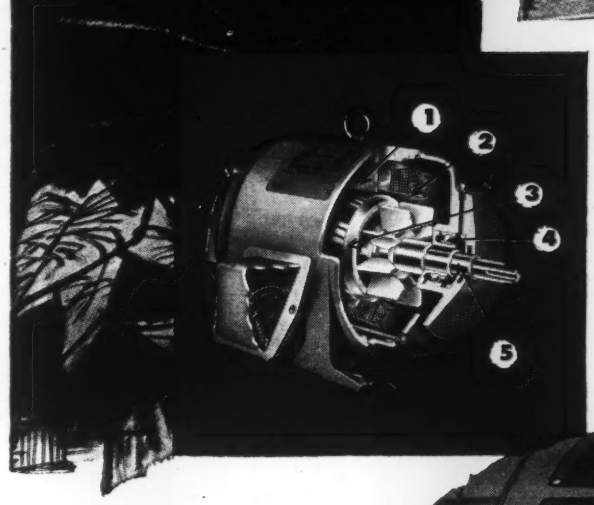

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Selecting Metals for Oil-Film Bearings

DESIGN ABSTRACTS

By E. B. Etchells
Chevrolet Motor Division
General Motors Corp.
Detroit, Mich.

SELECTION of the best metal to be used in plain oil-film or boundary-film bearing applications is dependent upon a number of requirements, including:

1. Score resistance
2. Deformability
3. Fatigue strength
4. Corrosion resistance
5. Cost.

The selection is not easy, since no one metal is available at present which is capable of meeting all the varied applications to which bearings are subjected. For one application fatigue strength may be the controlling requirement, whereas another application may require the very best score resistance with maximum corrosion resistance. The final selection of a bearing metal usually depends, to a great extent, on experience, judgment and compromise. The foregoing bearing requirements are, in some respects, interrelated, and the best choice for a bearing metal is made by recognizing first what the bearing requirements are and then selecting a commercial alloy having these qualities.

Research is being done continuously on perfecting bearing materials. The results of work that has been done have led to the conviction that a bearing metal will function properly during operation if it has a high endurance limit and load-carrying capacity, and if a soft, readily conformable metal can be plated in a thin layer on the working surface.

No order of importance is suggested by the following individually different requirements of a bearing. They all have their place in the selection of a metal to be used and in the design of the bearing itself.

Table 1—Score Resistance Properties of Common Bearing Metals

Bearing Material	Order of Score Resistance	Order of Hardness	Suggested Application
Brass-Bronze Alloys 85-90 Cu, 2 Fe, 4-10 Al	8	1	Very poor anti-score quality. Used in minor locations.
60-90 Cu, 10-40 Zn, 0-2 Pb	7	2	Very poor anti-score quality. Used in minor locations and with hypoid gear oils.
85-90 Cu, ½-3 Zn, 7-10 Sn, 0-5 Pb	6	3	For heavily-loaded* piston pins and similar motions where surface speed† is very low.
80-90 Cu, 0-5 Zn, 3-10 Sn, 5-10 Pb	5	4	Average bushing materials for low-speed, small-diameter shafts.
70-75 Cu, 4-10 Sn, 20-25 Pb	4	5	For moderate-speed bushings and where lubrication is not well maintained.
Aluminum Alloys	3	6	For heavily-loaded moderate-speed bearings.
Copper-Leads	2	7	For heavily loaded high-speed bearings.
White-Metal Alloys (Cadmium and Babbitts)	1	8	Low to moderately loaded, low to high-speed bearings where dirt and deflections are present.

* Conditions of load: Low, 1000 psi and under; moderate, up to 2,000 psi; high, over 3,000 psi. † Conditions of speed: low, 5-10 fps; moderate, 15-20 fps; high over 30 fps.

Score Resistance: The score resistance, or antiseizure character-

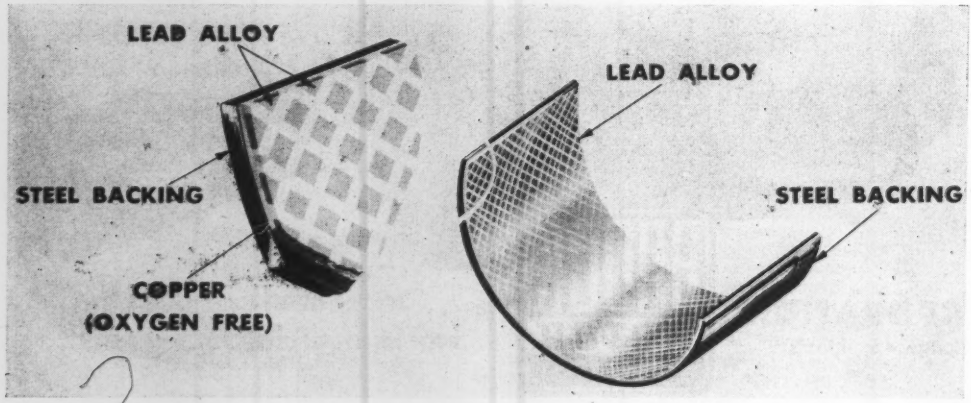

Fig. 1—Grid bearings in which aluminum, silver or copper-alloy bearing materials are indented with a fine grid pattern, then filled with lead alloy, offer improved score - resistance properties

Table 2—Deformability Characteristics of Bearing Metals

Bearing Material	Order of Fatigue Strength	Approximate Maximum Load (1000 psi)	Order of Deformability
Bronzes	1	10	7
Copper-lead (with tin or silver)	2	3-4	6
Thin babbitt overlays (0.003 in. or less)	3	2-4	5
Aluminum alloys	4	2-3	4
Copper-lead	5	1.5-2.5	3
Cadmium alloys	6	1.2-1.5	2
Lead and tin-base babbitts	7	0.8-1.5	1

Table 3—Standard Babbitt Metals

Metal Type	Composition (per cent) Tin	Antimony	Lead	Copper	Iron	Arsenic	Bismuth
SAE 10	90	4-5	0.35	4.0-5	0.08	0.1	0.08
SAE 11	86	6-7.5	0.35	5-6.5	0.08	0.1	0.08
SAE 12	88.25	7-8.5	0.35	2.25-3.75	0.08	0.1	0.08
SAE 13	4.5-5.5	9.25-10.75	86	0.5	...	0.6	...
SAE 14	9.25-10.75	14-16	76	0.5	...	0.6	...
SAE 15	0.9-1.25	14.5-15.5	remainder	0.6	...	0.8-1.1	...

istic, of metals used for bearings is often an important requirement. Scoring should not be confused with cutting or grooving of the metal by dirt or other foreign material. Most bearings are designed to run on oil films, but metal-to-metal contact may exist between the journal and the bearing due to starting, stopping, deflection and heavy loads. Bearings also are designed to operate continuously under partial or boundary-film conditions which produce rubbing contact at the surfaces. If the score resistance is not sufficiently high, the bearing metal will score, or ultimately seize, if severe enough operating conditions exist.

Of the many bearing metals available, the white metals are used where score resistance is a prime requirement. These white metals include the tin-base and lead-base alloys, commonly called babbitts. The relative order of common bearing metals in regard to score-resistance tendencies is shown in *Table* 1. It is evident that improved resistance to scoring is obtained at the expense of hardness and strength. A general classification, as listed in this table, does not allow the inclusion of special bearing metals, such as the tri-metal types for plain bearings.

Tin-base, white-metal alloys have been used with satisfactory results in machines where speeds and loads are light or, at most, fairly heavy. Their chief weakness, in cyclic-loaded bearings, is low fatigue life.

The aluminum alloys, as well as silver and copper, can be made to have improved score resistance by employing an indented, fine grid pattern and filling with lead alloy, *Fig.* 1, or simply overplating with tin or lead alloy. When this is done, score-resistance properties approach those of the white metals.

Deformability: The ability of a bearing to yield to deformation without failure during its operation is highly important. For a bearing to have good deformability properties, it should have good conformability and embedability characteristics.

When loads are applied to a structure, the bearings or journals deflect, often producing edge contact. If a bearing metal which is conformable is selected for the design, an adjustment is made without producing high temperatures that lead to a burned-out or fatigued bearing.

The embedability characteristic is important when dirt enters the clearance space, where it must embed in the bearing metal or cut a groove around the shaft and bearing. Silica (dust, core sand) or metal particles cause wear, particularly at low speeds, and overheating of the bearings at high speeds with hard metals.

Where dirt conditions are uncontrollable, white metals are preferred as the bearing metal, even though such a compromise results in a lowering of fatigue life. When copper-lead, bronze, or aluminum alloys are used as the bearing metal, it is good practice to harden the journals, thus reducing wear.

Frequently, the ability to embed when dirt is present and to conform when distortion is present, are treated as separate characteristics. In practice, a material responds about equally to each of these influences. In *Table* 2, this characteristic is shown as deformability.

The beneficial effect of lead-base babbitt overlays is seen by comparing identical materials with and without overlay. A relative embedability or dirt-tolerance improvement of from 10 to 100 times may be had, depending upon the thickness of the overlay and the character of the basic bearing metal under the steel backing.

Fatigue Strength: Fatigue

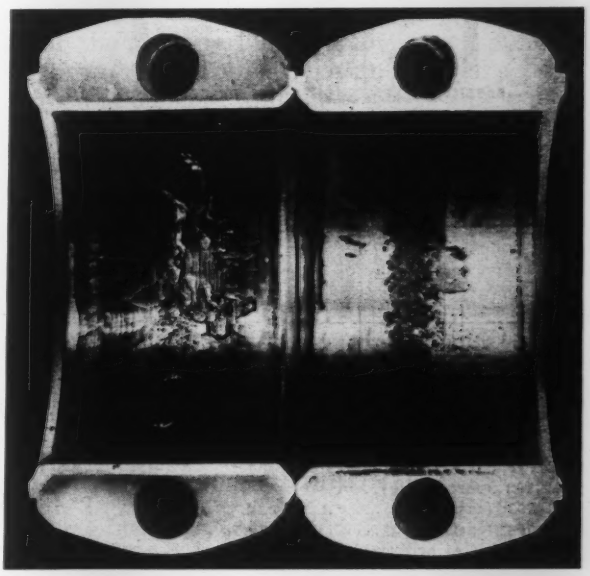

Fig. 2—Typical failure in a babbitt bearing from fatigue which starts as small cracks at the surface and works down to the bonding material

strength is important for bearings subjected to alternating or rotating loads. Well-known examples are the connecting-rod and main bearings, used in internal-combustion engines, which are subjected to rotating loads, and piston-pin bushings which are subjected to alternating loads. Bearing failure starts in the form of small surface cracks which work down to the bonding material and then progress parallel to the backing, *Fig.* 2. When a large enough portion of the bearing surface has fatigued, the oil-film conditions deteriorate to the point where failure by overheating quickly follows. Such failures should not be confused with those resulting from a bad bond, where the difficulty shows up very early and usually can be identified by no bonding material on the backing metal.

The operating conditions, especially time and temperature, design of the bearing housing and the amount of journal flexure, have so much influence that it is difficult to state specific loads. In *Table* 2, however, a guide to the maximum load is given.

The methods and techniques of manufacturing metals for plain bearings affect their fatigue strength. Performance of the white metals as bearing metals has been improved greatly by precision manufacturing to obtain thin overlays on a steel backing. The fatigue strength of aluminum alloys attain their highest value when securely bonded to a steel back. Long life, however, also can be found with solid aluminum-alloy bearings when the shells can be made thick and the temperature rise in the steel housing is not sufficient to cause permanent set.

The use of silver as a specialized bearing material was given impetus during World War II. It is widely used in aircraft engines because of its high fatigue strength, even under the most severe conditions. The aluminum alloy, silver and some copper-lead bearings are used with a thin overlay (0.002-inch thickness or less) of lead-base white metal to aid in the breaking-in process and to provide more tolerance to dirt and journal imperfections.

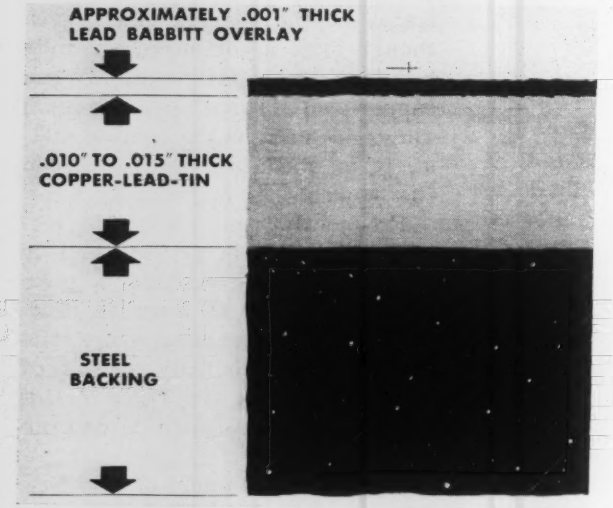

Fig. 3 — Tri-metal bearing material is used to obtain high load-carrying ability. The copper - lead - tin section gives high strength and a thin overlay of lead gives the bearing good score-resistance characteristics

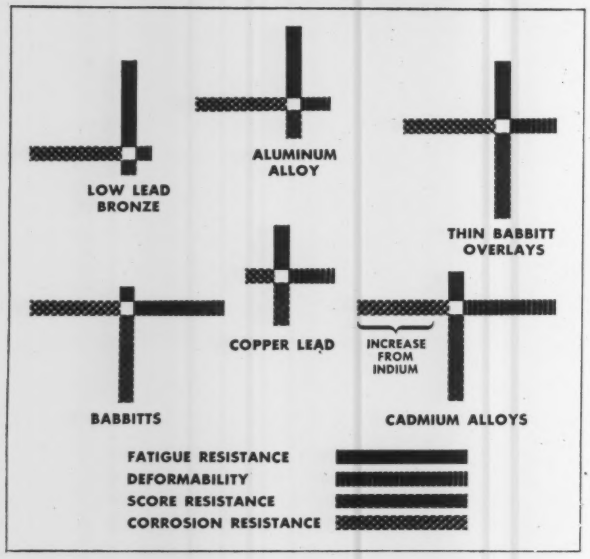

Fig. 4 — Functional chart shows the four most important bearing-metal requirements; the length of each line is a measure of approximate order

Corrosion Resistance: Bearing metals that are unalloyed are subject to corrosion by lubricating oils which contain acids or become acidic through oxidation. Copper, lead, cadmium, and silver are especially prone to corrosion. Fatigue will result in the bearing metal if corrosion becomes excessive.

Corrosion of copper by sulphur can be greatly reduced by alloying copper with zinc, but only with a loss of antifriction or antiseizure properties, as seen in *Table* 1. Lead-base alloys containing over

Table 4—Standard Brass and Bronze Bearing Alloys

Metal Type	Composition (per cent)										
	Copper	Tin	Lead	Zinc	Antimony	Nickel	Iron	Aluminum	Phosphorus	Silicon	Other
SAE 40 (cast lining).....	84–86	4–6	4–6	4–6	...	1	0.3	0.005	...	0.005	...
SAE 62 (cast lining).....	86–89	9–11	0.3	1–3	...	1	0.15	0.005	...	.....	...
SAE 64 (cast lining).....	78–82	9–11	8–11	0.75	0.5	0.5	0.15	0.005	0.25	0.005	...
SAE 68A (cast lining).....	86–89	0.5	...	...	...	...	2.5–4	8.5–9.5	...	....	...
SAE 791 (rolled or wrought)	remainder	3.5–4.5	3.5–4.5	1.5–4	...	...	0.1	....	...	....	0.2
SAE 792 (cast lining).....	remainder	9–11	9–11	0.5	0.5	0.5	0.35	....	...	....	0.4
SAE 793 (cast lining).....	83 min.	3.5–4.5	7–9	4	...	...	0.35	....	...	....	0.3
SAE 794 (cast lining).....	68.5–75.5	3–4	21–25	3	...	...	0.35	....	...	....	0.4
SAE 795 (rolled or wrought).	88–92	0.25–0.75	...	remainder	...	...	0.1	....	...	....	0.2

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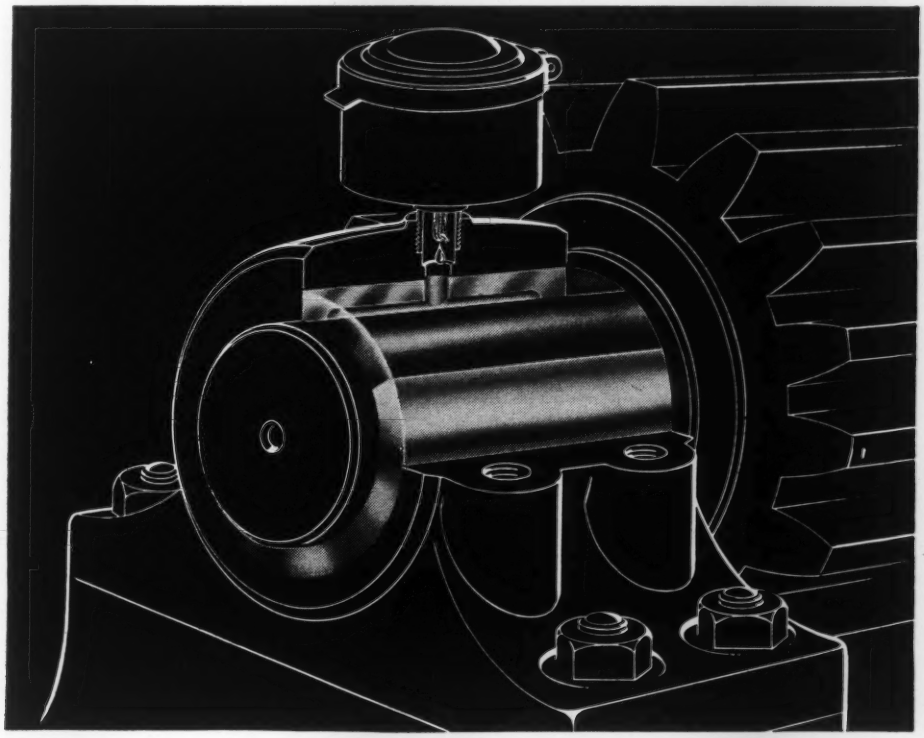
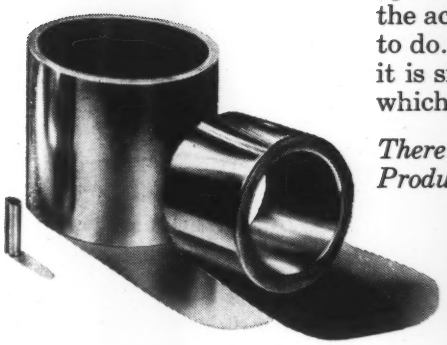
Cost of added parts



Give careful thought to the added parts required for the satisfactory functioning of some bearing types and not necessary with the simple uncomplicated sleeve bearing. Lock nuts and lock washers needed to fasten some bearing types to the shaft are absent in sleeve bearing design. With the sleeve bearing there is nothing to lock to the shaft. Intricate end covers required for locating or enclosing some types of bearings again are absent in sleeve bearing design. Where the sleeve bearing is to be of the floating type it is simply inserted by hand in the part in which it is to operate. The bearing is delivered to you ready for installation with the actual easy assembly in housing and on shaft all that is left to do. Where the sleeve bearing is to be of the pressed-in type it is simply pressed into the gear, gear box, lever or housing in which it is to function.



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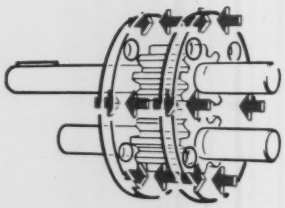

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Design Abstracts

3 per cent tin, or not less than 1 per cent tin and suitable amounts of antimony, arsenic, or indium, can be protected from acidic lubricants. Small amounts of indium can protect cadmium bearings.

Common bearing materials are classified as to their resistance to corrosion as follows:

Noncorrodible
Aluminum alloys
Tin-base babbitt
Lead-base babbitt
Cadmium-indium alloys
Low lead bronzes

Intermediate
High lead bronzes
Copper-lead
Alkali-hardened lead
Silver

Corrodible
Cadmium alloys

This listing should be used with discretion since the intermediate and corrodible alloys may reverse their activity in the presence of certain lubricants. Bearing corrosion has now been greatly diminished due to detergents and inhibitors which presently are being added to lubricating oils.

Cost: The selection of the proper bearing metal may, more often than not, be influenced by cost. There are, no doubt, instances where the cost of a single bearing may be small as compared to the total cost of the machine. This is not an engineering justification, however, for deliberately using silver if a simple bronze bushing would be satisfactory. The approximate order of increasing cost of bearing metals is as follows:

1. Bronze bushings
2. Lead-base babbitt
3. Tin-base babbitt
4. Sintered copper—Nickel filled with lead babbitt
5. Aluminum alloys (solid)
6. Cadmium alloys
7. Copper-lead
8. Copper-lead with thin overlay
9. Aluminum alloy with thin overlay
10. Silver with thin overlay

Metal Properties: The properties which a bearing metal must have if it is to perform its function properly can be divided into three main classes:

1. Proper structure
2. Satisfactorily balanced mechanical properties
3. Easy melting, casting, and bonding properties.

A bearing metal has proper

structure if it has a soft matrix with sufficient plasticity to conform to slight irregularities in the machining and alignment of the shaft and to allow any abrasive particles in the lubricant to become embedded.

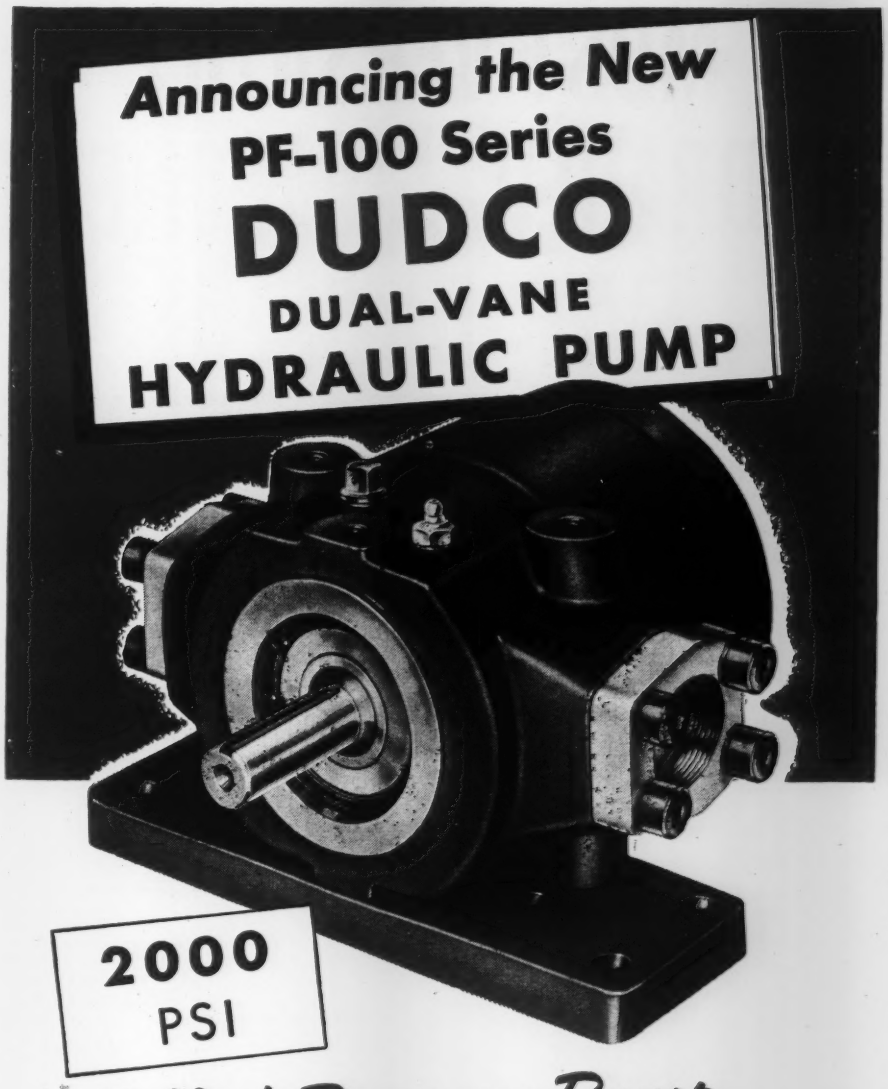
If a bearing metal has balanced mechanical properties it resists the shock of impact loads, has sufficient strength, ductility, and resistance to compression, and does not crack or squeeze out under heavy loads in applications involving high temperatures.

Easy melting, casting, and, most important, good bonding properties are especially desired in a bearing metal. The metal must adhere firmly to the steel piece used as a backing and should not chip off or separate from the backing during operation.

Babbitt Metals: In choosing a metal to be used as a bearing, the tin-base and lead-base alloys (babbitts) should be given careful consideration because of their ease of handling and low cost. It is necessary with either the tin-base or lead-base alloys to have a minimum lining thickness properly bonded to a steel back, consistent with the conformability and embedability requirements of the application, to secure maximum load-carrying ability and fatigue life at elevated temperatures. Lead-base bearings have the advantage of lowest cost but their ability to support high loads with low oil temperatures is less than the tin-base babbitts when thick linings are used. When the thickness is less than about 0.0005-inch, however, no appreciable difference is to be found in load-carrying ability at high temperatures of the numerous types of lead-base compositions.

Babbitt linings of 0.003 to 0.008-inch thickness are common in commercial automotive engines, with 0.002-inch the low limit. Large stationary engines use thicknesses from 0.020 to 0.060-inch. The S.A.E. standard babbitt metals are given in *Table* 3.

Copper-lead Alloys: Copper-lead bearings are backed by steel to



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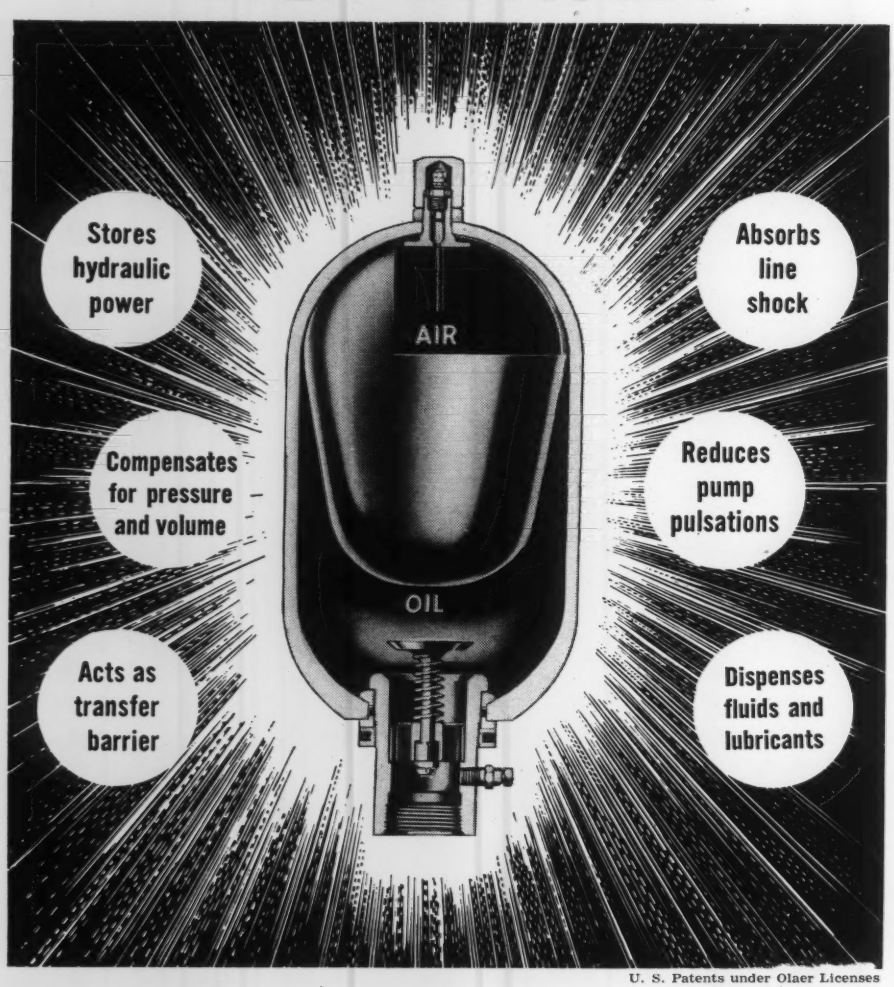

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give strength and rigidity. They are widely used where loads are higher than can be carried by the babbitts and are made by casting or by the sintering process using powdered metals. Standard copper-lead bearing alloys specified by the S.A.E. are:

1. *SAE* 48: 67-74 Cu, 25-32 Pb, 1.5 Ag, 0.1 Zn, 0.025 P, 0.35 Fe, 0.15 other elements.
2. *SAE* 480: 60-70 Cu, 30-40 Pb, 0.35 Fe, 0.05 Sn, 0.3 other elements.

The higher lead-content alloy gives a higher antiscore characteristic, but at the expense of strength, and is inferior in compression properties to the other copper-rich alloys. In general, however, the high lead-content alloys are superior to the white metals in load-carrying ability and their properties are not so much affected by operating temperatures. They are also more resistant to repeated flexure, which is important with present-day engine speeds.

To obtain higher strength, tin up to 3 per cent and silver up to 5 per cent are added at a sacrifice of antiscore quality. The tendency of such an alloy to score can be offset by overplating with a thin coating of lead alloy which results in one of the highest load-carrying plain bearings now in modern use. These are commonly known as tri-metal materials, *Fig.* 3.

Bronzes: Bronzes are valuable because of their low cost and wide range of characteristics, as determined by the many various compositions. They are especially resistant to wear when used with hard shafts or journals.

The number of commercial bronzes is very large. The S.A.E. specifications in *Table* 4 can be used as a guide in conjunction with *Table* 1, which gives suggested applications for their use.

Aluminum Alloys: Aluminum as a bearing material is not new, but the metal's high coefficient of thermal expansion and bonding characteristics heretofore have been severe drawbacks. Recent research has led to the development of alu-

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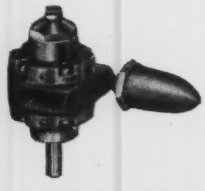

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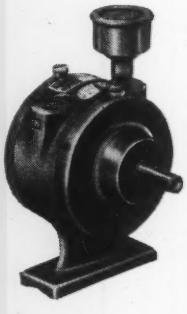

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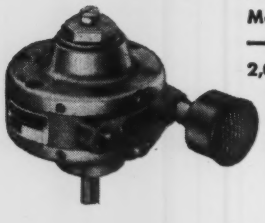

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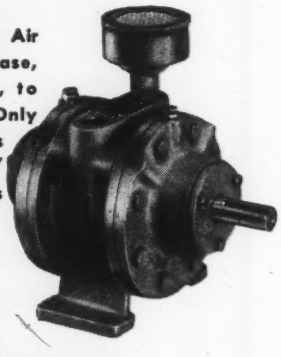

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Compositions of three aluminum bearing materials are:

1. *XB-80S:* 1.0 Cu, 1.0 Ni, 6.5 Sn, remainder Al.
2. 750: 2.5 Si, 1.0 Cu, 0.5 Ni, 6.5 Sn, remainder Al.
3. *GM-3889M:* 1.0 Cd, 4.0 Si, remainder Al.

Alloy XB-80S is a strip alloy and includes a steel backing, whereas alloy 750 is furnished without steel backing. GM-3889M material was developed by General Motors Research Laboratories Division and is used in the Moraine-400 bearing, manufactured by the Moraine Products Division. This material is produced by the strip process and is bonded to a steel backing. The finished bearing carries a lead-tin-copper overlay not exceeding 0.001-in. in thickness and possesses excellent ductility and score-resistant properties. This lead-base electrodeposit includes sufficient tin to prevent corrosion. The addition of copper to the composition gives the overplate alloy strength and load-carrying ability, enabling the bearing to operate satisfactorily and withstand the fatiguing stresses imposed by the heavily loaded modern engines.

The Moraine-400 bearing metal is another tri-metal material which may be classified in the moderate-cost, high-load, high-speed group and offers from six to ten times the bearing life of the conventional babbitt bearing material.

Cadmium Alloys: The cadmium alloys are used in very special designs where their additive cost is justified by the increase in fatigue life. S.A.E. specifications, which are essentially the same as may be obtained commercially, are as follows for two standard cadmium bearing alloys:

1. *SAE* 18: 98.4 Cd, 1.0-1.6 Ni, 0.01 Ag, 0.2 Cu, 0.02 Sn, 0.05 Pb, 0.05-0.15 Zn.
2. *SAE* 180: 98.25 Cd, 0.5-1 Ag, 0.4-0.75 Cu, 0.01 Sn, 0.02 Pb, 0.02 Zn.

The cadmium alloys are attacked by corrosive oils unless treated

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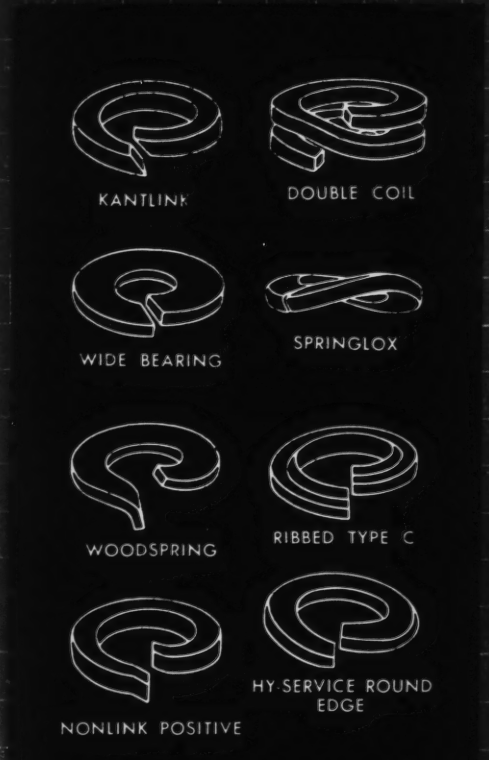

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Design Abstracts

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Miscellaneous Alloys: Two special types of bearing materials that are important commercially, but restricted to specific applications, are zinc castings and the porous type of sintered, powdered metal.

Zinc castings are used where low cost is desired and where speed and loads are low. Zinc and its alloys are not good antifriction metals and will score readily when speeds and loads become too high.

Sintered, powdered metal bearings are known as the oilless or self-lubricating bearings. The most common oilless bearing is made by compacting 87.5 to 90.5 per cent copper powder, about 9 per cent tin powder and about 1.5 per cent graphite. The bearings are made with a controlled number of voids so that, when installed, they contain 15 to 35 per cent impregnated oil. They are, therefore, both bearing and lubricant and, if properly made, function for life in specific applications.

Design Role: The determination of the metal to be used for bearing applications is not a simple one. A complete knowledge of the actual conditions under which an oil-film bearing is to operate is essential in order that a decision can be made as to the requirements the bearing must meet. With the operating requirements known, the selection of a bearing metal can then be made, usually involving a compromise of all the various factors which have been discussed.

The functional chart, *Fig.* 4, shows the four most important bearing metal requirements. Because it is very difficult to assign exact values to these properties, the length of each line may be taken as a measure of approximate order. The selection of the proper bearing metal for any application usually evolves itself into an art in which competent experience plays an important part. When new problems and conditions arise, it may be necessary for even the most experienced person to obtain new data.

From an article entitled "How Engineers Select Metals for Oil-Film Bearing Applications" appearing in the General Motors Engineering Journal for March-April, 1954.

Electrical Braking of AC Motors

By H. W. Jones

Control Engineering
Standard Control Div.
Westinghouse Electric Corp.
Beaver, Pa.

WHILE mechanical brakes are probably still the most widely used method for stopping motors, there are also several effective methods of electrical braking. The more common electrical methods are plugging, dynamic braking, regenerative braking, capacitor braking (for limited application to induction motors), and dc braking, all of which may be applied to standard motors.

Plugging: This method consists of the application of voltage, by means of a reversing contactor, tending to reverse the direction of rotation of the motor. To prevent the motor from actually reversing, this voltage must be removed as the motor speed approaches zero. This is accomplished by using a zero-speed switch which is mechanically coupled to the motor shaft.

The losses to stop the motor are approximately three times as great as the losses while accelerating the motor from zero to synchronous speed. If full voltage is applied for plugging, there can be considerable line disturbance. This is not as objectionable now as it was a few years ago, as the increased capacity of the feeder systems tend to minimize this. The degree of plugging with an increase in the stopping time can be controlled by using either a reduced voltage source or equal resistors in the three motor lines. This also reduces line disturbances.

Dynamic Braking: This means of braking is obtained when a motor is allowed to function as a generator with its output being expended as a loss. An inherent characteristic of this type of braking is the

decrease in its effectiveness as the speed decreases. Usefulness of this method is limited to applications where the motor is coupled to a friction load.

Regenerative Braking: Because it is obtained by operating a motor above its synchronous speed, regenerative braking is also very limited in use. With a constant frequency source, its most important use is in providing positive slowdown from high to low speed of a multispeed motor.

Capacitor Braking: In an induction motor, it is necessary that apparatus connected in parallel supply a leading power factor. Capacitor braking is the use of capacitors connected across two or three of the phases to meet this condition. Resistors can also be used in parallel with the capacitors during the braking cycle. With this method, very little braking effort is obtained below about one-third synchronous speed.

Dc Braking: Application of direct current to one or more of the stator windings of an ac induction motor to produce a braking torque is by no means new or novel. However, the use of individual motors and the development of suitable means of obtaining direct current without rotating machinery has recently placed this method of braking on a more equal footing with the other available methods of controlling the deceleration of ac motors.

For all practical purposes, dc braking can be considered a special case of regenerative braking in which a voltage of zero frequency is applied to the motor terminals. Thus, synchronism occurs at zero speed and the motor is converted into a brake that opposes rotation in either direction. The familiar characteristic of regenerative braking is obtained; that is, the braking effort increases as the rotor speed decreases, reaching a maximum value at approximately one-fourth of synchronous speed and then dropping off very rapidly as the rotor speed approaches zero.

Dc current is applied to one phase of the motor by means of a reversing starter which is used for alternately connecting the ac and dc sources to the motor. As dc is generally not available, a rectifier and an appropriate transformer are used. The transformer serves as a means for adjustment and for limiting the maximum available current. Since it is desirable to keep motor heating to a minimum, a timing device is included which is adjusted to remove the braking current immediately after the speed of the rotor has reached zero. This also keeps heating of the components within the enclosure to a minimum. A condenser discharge type of timing circuit is generally used because of the short time usually required to stop the motor. A mechanical timer is used on those applications involving high inertia loads with little inherent friction where dc braking is used as a retarding force to provide a smooth and comparatively fast stop.

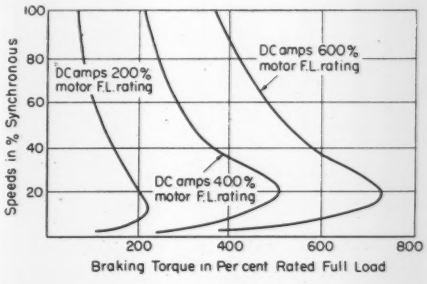
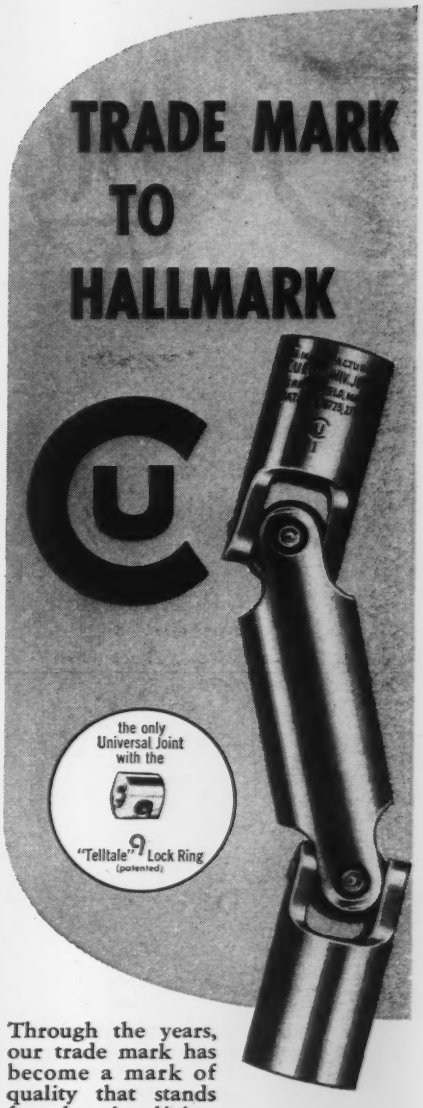


Fig. 1 — Typical braking-torque curves for a 4-pole squirrel cage motor at various values of dc braking current

Dc braking is applicable to squirrel cage or wound-rotor polyphase motors and can also be used with equal effectiveness in single phase motors. A wound-rotor motor with some resistance in the secondary will produce more braking torque for a given dc current than a squirrel-cage motor of the same horsepower.

Electrical Characteristics: A family of typical braking torque curves for a 4-pole squirrel-cage motor with various values of direct current applied on one phase is shown in *Fig.* 1. The current values are expressed as a per cent of the motor full-load ac rating. Due to saturation, stresses set up and heating, it is not advisable to use



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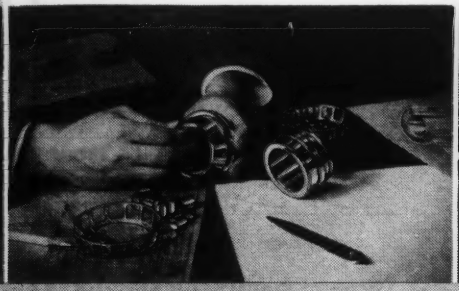

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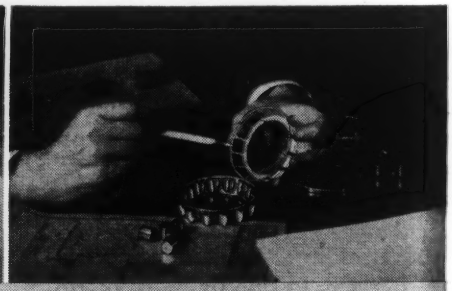

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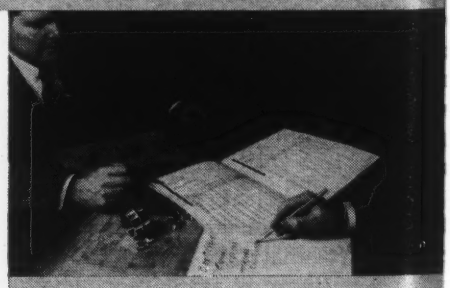

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a current that exceeds the locked rotor current. The average braking torque, using a direct current of 200 per cent of motor full-load current, is about 120 per cent of rated full load torque. If the direct current is increased to 400 per cent, the average braking torque increases to about 325 per cent.

Comparative braking torque curves of a motor for full-voltage plugging and dc braking with a direct current of 200 per cent rated full load current are plotted in *Fig.* 2. The average braking torque during plugging is 175 per cent of the rated full load torque.

If a load with a WR^2 value equal to twice that of the rotor is placed on this motor, plugging will stop this load in about 0.7 second or 10 revolutions. Dc braking will

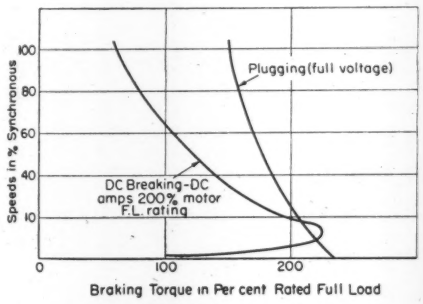

Fig. 2—Braking torque curves for a 4-pole squirrel cage motor with full voltage plugging and dc braking with a direct current of 200 per cent rated full load current

stop this load in about 1.3 seconds or 20 revolutions. Increasing the dc braking current to 400 per cent will decrease the time to 0.4 second and the revolutions to 5.

Frequently, the stored energy of the rotor represents a large portion of the total energy of the system. As in the other methods of electrical braking, the rotor energy does not have to be dissipated through the motor shaft. On applications involving too much braking torque for the motor shaft or coupling, a solenoid brake can be used in conjunction with dc braking with the brake acting on a shaft in the machine instead of on the motor shaft.

With dc braking, once the braking effort has been determined and the dc current necessary to give

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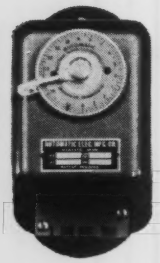

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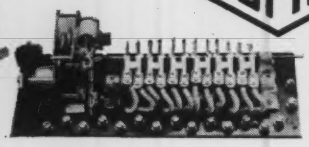

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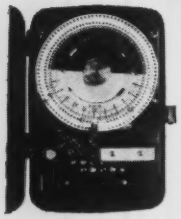

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the desired braking action has been set, consistent braking with no periodic adjustments is obtainable.

As both dc braking and plugging introduce heat into the motor, applications with very short duty cycles and relatively high inertia loads or applications involving very high inertia loads must be given careful consideration before selecting either of these methods of braking.

Dc braking offers a method of stopping a motor without mechanical apparatus attached to the motor shaft and without maintenance other than that normally required for control apparatus. It provides a smooth rolling stop without the possibility of reverse rotation. There is, however, no holding torque at the end of the braking cycle. Also, there will be no braking torque when the main ac supply fails. This, of course, can partially be overcome by using a separate source of power to obtain the braking current.

Selection Factors: Dc braking can be used very successfully where any of the following characteristics are desired:

1. Rapid and/or controlled stopping.
2. Frequent operation with a minimum of maintenance.
3. Smooth, vibrationless acceleration without shock to the drive.
4. Assurance that the motor will not rotate in the reverse direction.
5. Ability to rotate the motor manually without requiring power applied to any component.
6. Same degree of braking if motor is operating in either direction.

While general cost figures cannot be accurate, it is safe to say that the least expensive type of brake is a solenoid type magnetic brake. Plugging and dc braking are about the same in cost, depending upon the degree of control required and the size of the motor. Capacitor braking is probably the most expensive.

In the final analysis, type of braking must be selected on the basis of size, configuration and location, functions to be performed, degree of control to be maintained and, of course, price, which in-

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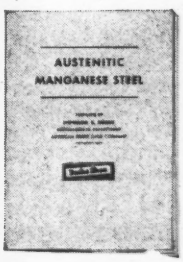

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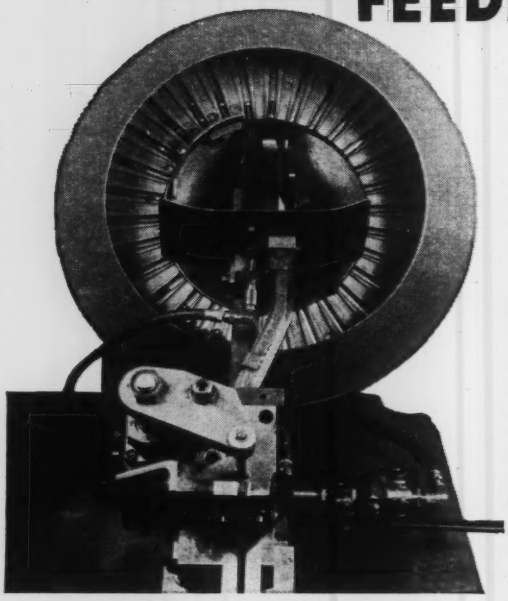

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From a paper entitled "A Comparison and Evaluation of Dc Braking" presented at the 18th annual Machine Tool Electrification Forum sponsored by the Westinghouse Electric Corp. in Buffalo, N. Y., April, 1954.

Post-Forming of Thermosetting Laminates

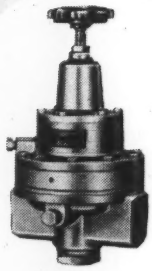
By St. John Bain

Engineer
The Formica Co.
Cincinnati, O.

ALTHOUGH laminated plastics have been manufactured commercially since 1913, the discovery that cured sheets of this type of plastic material could be bent to various curvatures and relatively sharp radii did not take place until 1943. At that time it was found that by "flash" heating a phenolic-cotton fabric laminate to a point just below its blistering temperature, it could be successfully formed. To this process of heating and bending a cured sheet of laminated plastic, the term "post-forming" was assigned. This process of obtaining a formed part made of a thermosetting laminate is fundamentally different from the molding process, in which the impregnated material is actually cured in a heated mold under high pressure to the desired shape.

Resins for Post-Forming: There are two basic types of plastic resins: (1) thermoplastic resins and (2) thermosetting resins. The flexibility of the thermoplastic type, after being cured, is a function of the temperature of the material. Therefore, it can be heated and formed and reformed an infinite number of times. A well-known example of this type of plastic is methyl methacrylate (Lucite or Plexiglas).

Thermosetting resins after being cured cannot normally be softened with heat. As a matter of fact, normal long-time baking actually makes a thermosetting resin more



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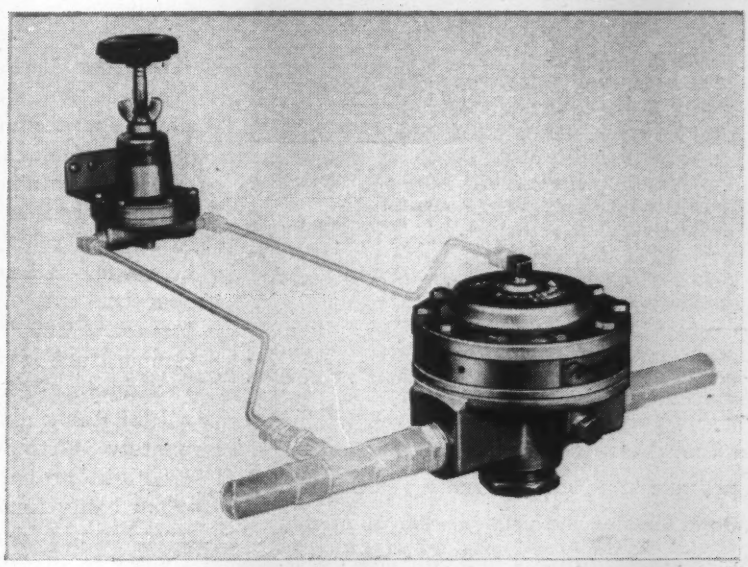

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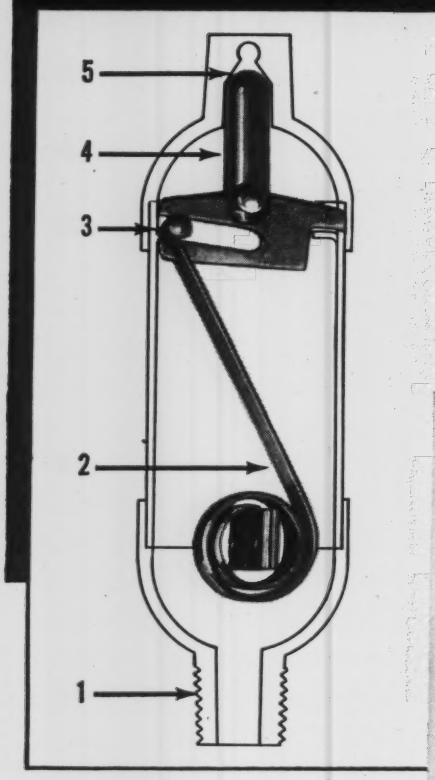

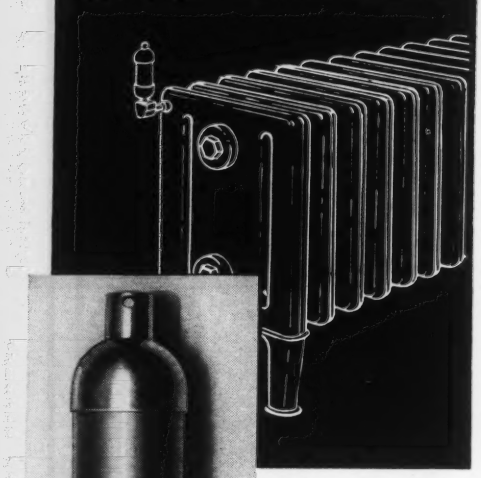

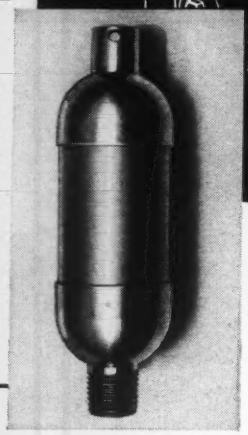

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In operation, the pressure of steam forces air out of radiator, into Tony Valve at fitting (1), through body of valve and out at (5). After cold air is completely exhausted and heat enters body of valve, thermostatic bimetal element (2) bends, moving pin (3) to left in slot in arm of plunger assembly (4). As left end of arm is locked in body, plunger is forced down into seat at (5) closing vent and sealing radiator and valve against further release of pressure.

This simple, positive and trouble-free unit releases pressure only when cold and closes only when warm to eliminate the old problems of pressure operated valves. All parts of the Tony Valve are of brass except the bimetal element.

This is but one of the many uses of Chace Thermostatic Bimetal in controls and recording apparatus. If you are interested in temperature responsive devices, read "Successful Applications of Chace Thermostatic Bimetal". Write today for this 36-page booklet which contains applications and 10 pages of engineering data on thermostatic bimetal.

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Design Abstracts

brittle. This is exactly opposite to what happens to a thermoplastic resin.

A thermosetting plastic laminate is made by impregnating some base material, such as various types of paper or fabric, with a heat-reactive resin. The impregnated material is then cut to a desired sheet size and a number of the sheets, depending upon the thickness desired in the final laminate, are built up one on top of the other. This built-up assembly is then cured at high temperature and pressure to form a solid sheet.

Heating Techniques: The heating operation is the most important single operation in the post-forming process. Because the temperature range in which a thermosetting laminate can be successfully post-formed is relatively narrow, it is necessary to have uniform heating over the entire area that is to be formed. This relatively narrow temperature range is limited by two factors. First, the material will blister when it reaches approximately 347 to 356 F. Second, there is high probability of cracking when being formed if the material temperature drops below 290 or 300 F. In view of these two limiting factors, uniform heating is vitally important and necessary for obtaining optimum forming results with a thermosetting laminate.

Several methods are employed for obtaining this very critical heating process. First, for heating various size industrial laminates, there are recirculated hot air ovens, infrared bulb ovens, and hot oil baths.

Infrared bulb ovens provide a good uniform heat source, are easy to load, and eliminate the need of cleaning the formed part. This type of heating is being used by the majority of post-forming fabricators who are processing industrial laminates. There are two types of infrared ovens being used: (1) direct radiation, (2) indirect radiation and convection.

In both cases, best results are obtained with clear infrared bulbs and special contoured, gold-plated reflectors that are designed specifically for uniform radiation.

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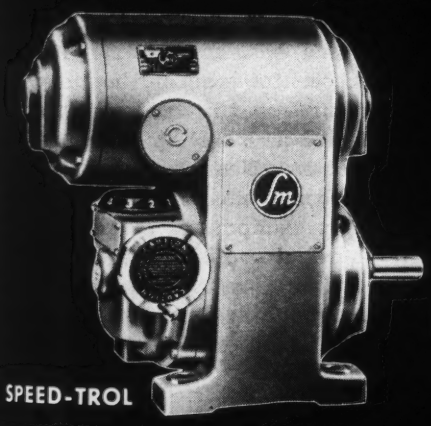
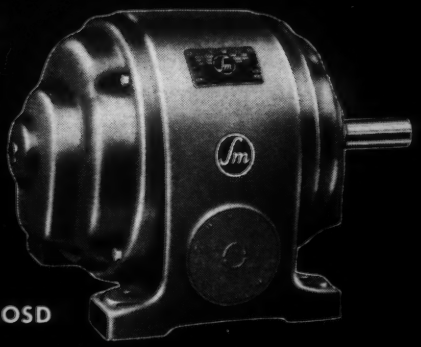


SPEED-TROL

LOW SPEED

SLO-SPEED

CONSTANT NORMAL SPEED



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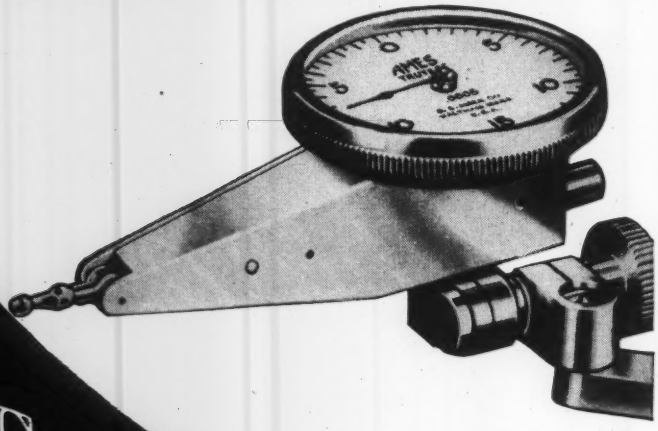

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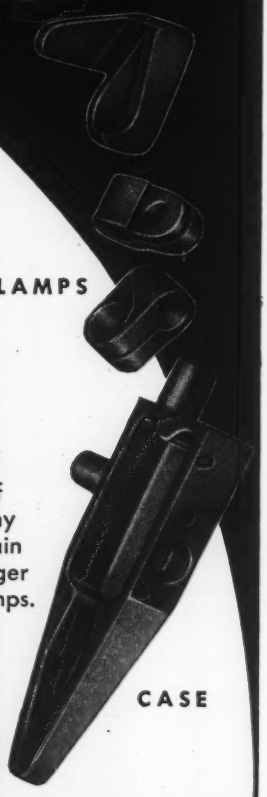
HITCHINER INVESTMENT CASTINGS permit, with only a few exceptions, complete freedom in the choice of ferrous or non-ferrous metals. The Ames Company chose beryllium copper for the clamp castings to gain proper metal density, freedom from fatigue, and longer life at much lower costs than machined steel clamps.



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Design Abstracts

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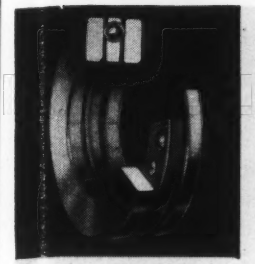

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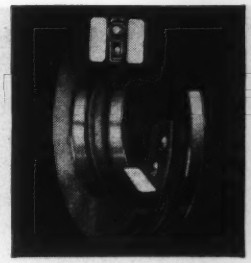

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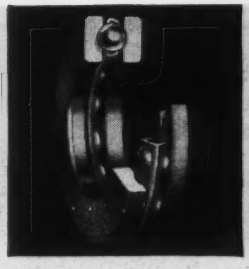

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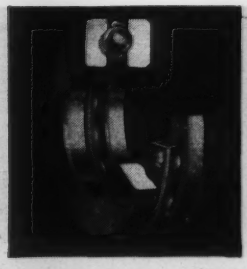

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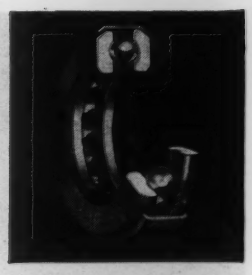

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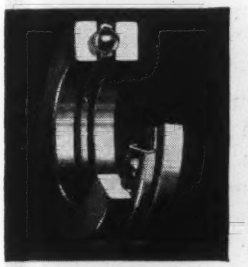

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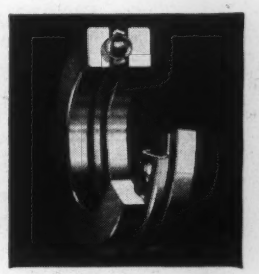

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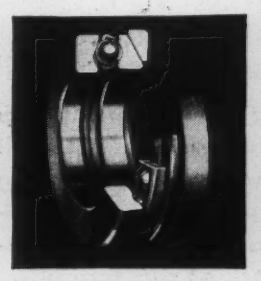

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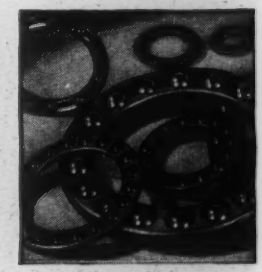

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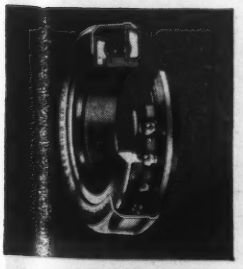

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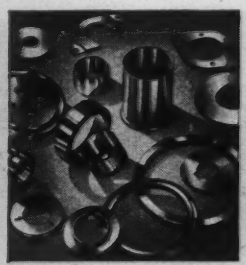

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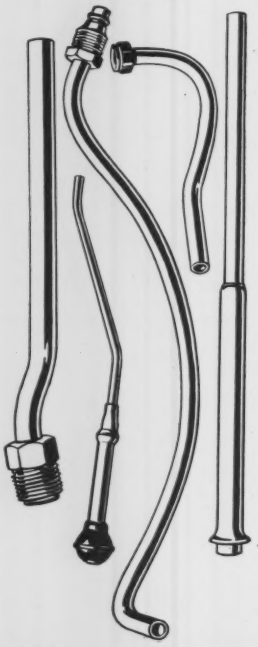

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Forming Limits: At the present time there are four distinctly different grades of thermosetting laminates being post-formed: (1) phenolic-cotton fabric laminate, (2) phenolic paper laminate, (3) phenolic-nylon fabric laminate and (4) combination melamine - phenolic paper laminate.

The first three are primarily for industrial applications; the fourth is for decorative applications. Of the four types, the first and fourth are used in much larger volume than the other two.

The minimum bending radii obtainable will quite naturally vary with the grade used and the thickness of the particular grade. For example, a post-forming grade of phenolic-cotton fabric laminate $\frac{1}{16}$-inch thick can be formed to a $\frac{3}{32}$-inch radius. The same grade $\frac{1}{4}$-inch thick can be formed to no smaller than a 1-inch radius. Phenolic-paper laminates, post-forming grade, can be formed to approximately the same minimum radii as the phenolic-cotton fabric laminates. However, there will be a noticeable color change and crazing on the bend area of the formed paper laminate because of the nature of the special creped paper that is used to give equal formability in all directions of the sheet. The minimum bending radii for various thicknesses of a phenolic-cotton fabric laminate as listed in an existing specification for industrial post-forming material are shown in *Table* 1. This specification has been issued by the Society of Automotive Engineers and has the designation *Aircraft Material Specification, AMS* 3605. The National Electrical Manufacturers Association (NEMA) has also prepared a specification for an indus-

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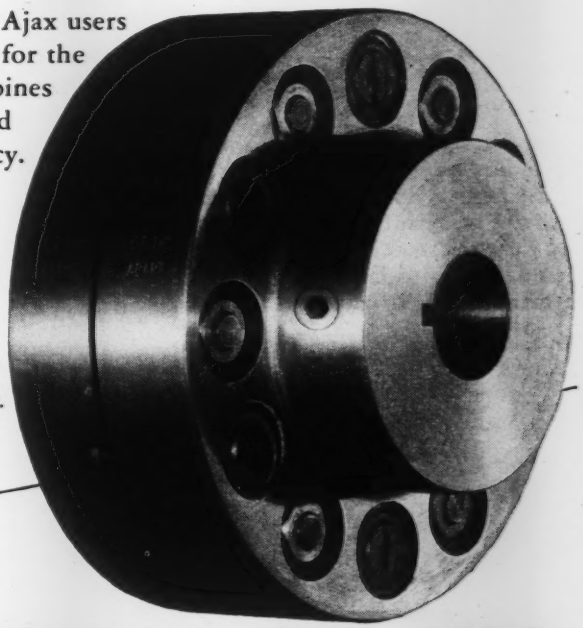

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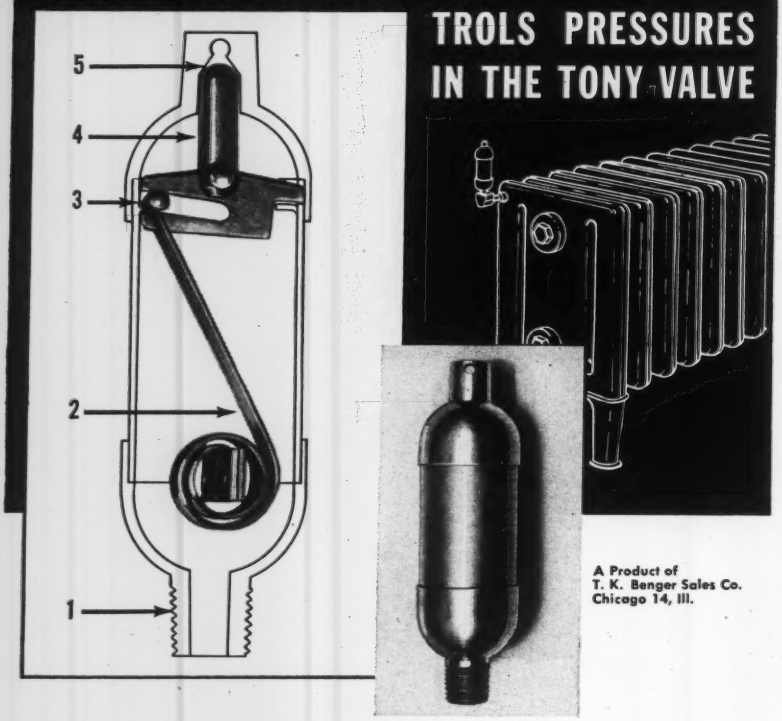

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One of the age-old problems of releasing trapped cold air from steam radiators has been solved in the Tony Valve by the use of Thermostatic Control rather than by relying on pressure to actuate the venting mechanism. By using a coil of Chace Thermostatic Bimetal, the vent remains open until the heated steam travels the full length of the radiator and only then closes, after all of the trapped cold air has escaped.

In operation, the pressure of steam forces air out of radiator, into Tony Valve at fitting (1), through body of valve and out at (5). After cold air is completely exhausted and heat enters body of valve, thermostatic bimetal element (2) bends, moving pin (3) to left in slot in arm of plunger assembly (4). As left end of arm is locked in body, plunger is forced down into seat at (5) closing vent and sealing radiator and valve against further release of pressure.

This simple, positive and trouble-free unit releases pressure only when cold and closes only when warm to eliminate the old problems of pressure operated valves. All parts of the Tony Valve are of brass except the bimetal element.

This is but one of the many uses of Chace Thermostatic Bimetal in controls and recording apparatus. If you are interested in temperature responsive devices, read "Successful Applications of Chace Thermostatic Bimetal". Write today for this 36-page booklet which contains applications and 10 pages of engineering data on thermostatic bimetal.

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Design Abstracts

brittle. This is exactly opposite to what happens to a thermoplastic resin.

A thermosetting plastic laminate is made by impregnating some base material, such as various types of paper or fabric, with a heat-reactive resin. The impregnated material is then cut to a desired sheet size and a number of the sheets, depending upon the thickness desired in the final laminate, are built up one on top of the other. This built-up assembly is then cured at high temperature and pressure to form a solid sheet.

Heating Techniques: The heating operation is the most important single operation in the post-forming process. Because the temperature range in which a thermosetting laminate can be successfully post-formed is relatively narrow, it is necessary to have uniform heating over the entire area that is to be formed. This relatively narrow temperature range is limited by two factors. First, the material will blister when it reaches approximately 347 to 356 F. Second, there is high probability of cracking when being formed if the material temperature drops below 290 or 300 F. In view of these two limiting factors, uniform heating is vitally important and necessary for obtaining optimum forming results with a thermosetting laminate.

Several methods are employed for obtaining this very critical heating process. First, for heating various size industrial laminates, there are recirculated hot air ovens, infrared bulb ovens, and hot oil baths.

Infrared bulb ovens provide a good uniform heat source, are easy to load, and eliminate the need of cleaning the formed part. This type of heating is being used by the majority of post-forming fabricators who are processing industrial laminates. There are two types of infrared ovens being used: (1) direct radiation, (2) indirect radiation and convection.

In both cases, best results are obtained with clear infrared bulbs and special contoured, gold-plated reflectors that are designed specifically for uniform radiation.

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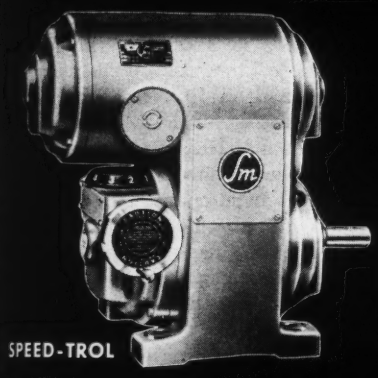

SPEED-TROL

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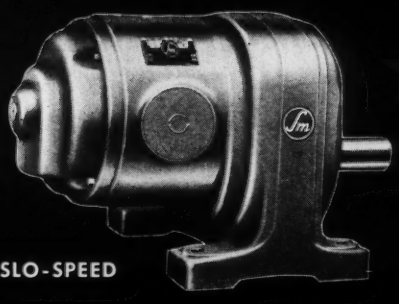

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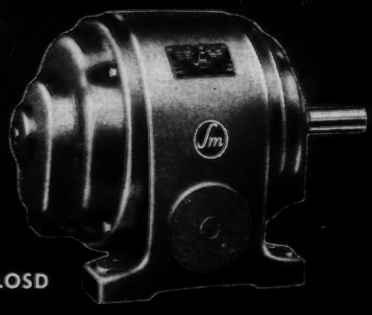

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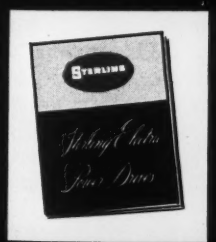

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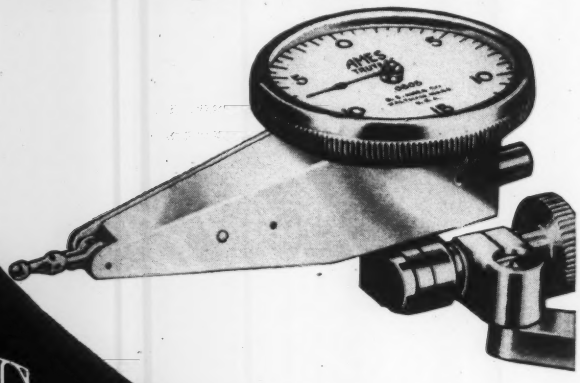

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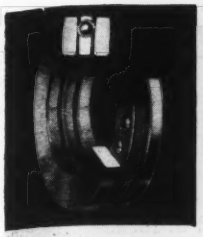

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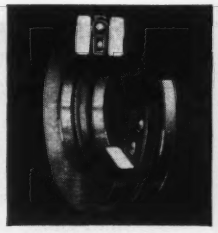

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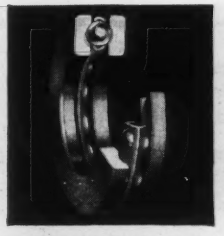

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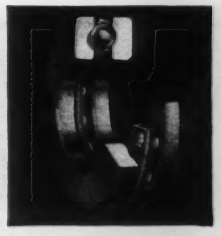

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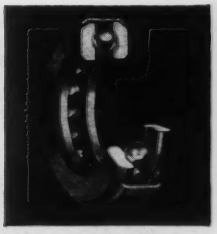

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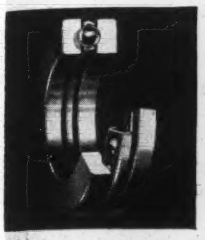

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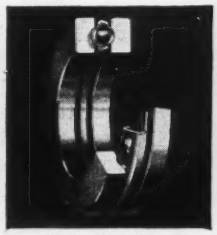
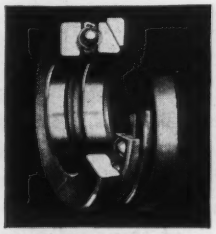


1100 SERIES • Medium duty ball thrust bearing. Grooved races. Pressed steel or bronze (large sizes) retainer . . . 23 metric sizes 10 to 140 mm. I.D.



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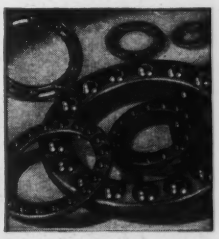
W SERIES • Case hardened and ground flat washers for various Thrust and Spacer applications. Slip fit. 38 sizes ½" to 3½" I.D.



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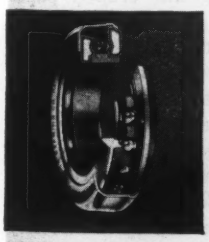

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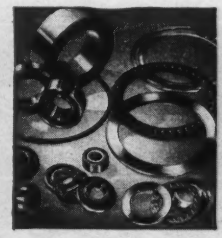

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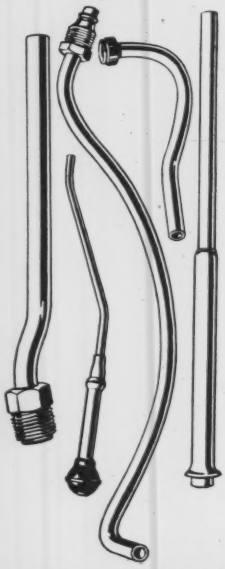

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Design Abstracts

Dies and fixtures are made with the same precision as those used in fabricating metal. However, the pressures necessary for post-forming plastic laminates are much less than those used in forming metals. A pressure of 10 psi or lower will be satisfactory 99 per cent of the time. Therefore, the die material can be lighter in weight and less expensive than most metal-forming dies.

Forming Limits: At the present time there are four distinctly different grades of thermosetting laminates being post-formed: (1) phenolic-cotton fabric laminate, (2) phenolic paper laminate, (3) phenolic-nylon fabric laminate and (4) combination melamine - phenolic paper laminate.

The first three are primarily for industrial applications; the fourth is for decorative applications. Of the four types, the first and fourth are used in much larger volume than the other two.

The minimum bending radii obtainable will quite naturally vary with the grade used and the thickness of the particular grade. For example, a post-forming grade of phenolic-cotton fabric laminate $\frac{1}{16}$-inch thick can be formed to a $\frac{3}{32}$-inch radius. The same grade $\frac{1}{4}$-inch thick can be formed to no smaller than a 1-inch radius. Phenolic-paper laminates, post-forming grade, can be formed to approximately the same minimum radii as the phenolic-cotton fabric laminates. However, there will be a noticeable color change and crazing on the bend area of the formed paper laminate because of the nature of the special creped paper that is used to give equal formability in all directions of the sheet. The minimum bending radii for various thicknesses of a phenolic-cotton fabric laminate as listed in an existing specification for industrial post-forming material are shown in *Table* 1. This specification has been issued by the Society of Automotive Engineers and has the designation *Aircraft Material Specification, AMS* 3605. The National Electrical Manufacturers Association (NEMA) has also prepared a specification for an indus-

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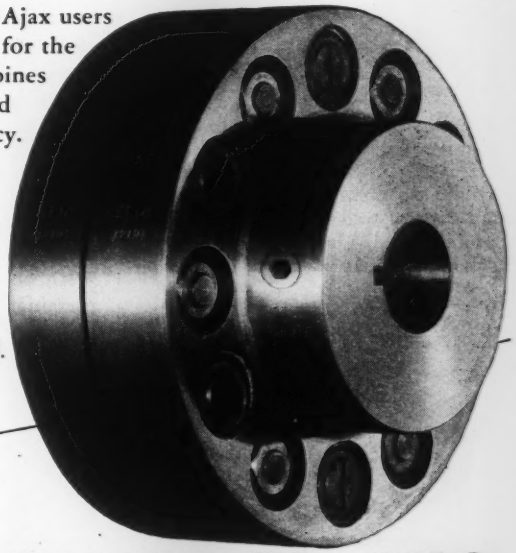

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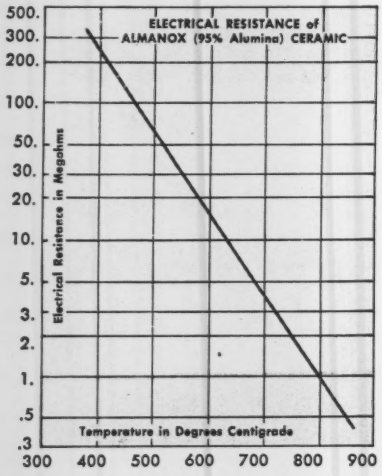

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Design Abstracts

trial post-forming laminate. In addition, there now exists a new military specification for similar material. Its designation is *MIL-P-8655 (Aer), Plastic Material, Laminated, Thermosetting Sheets, Cotton-Fabric-Base, Post-forming.*

Not much data are available on the bending limitations of the phenolic-nylon laminate. However, this type generally has forming characteristics similar to those of the phenolic-cotton fabric material.

Table 1—Bending Limitations for Phenolic-Cotton Fabric Laminate

Laminate Thickness (in.)	Minimum Bending Radius (in.)
$\frac{1}{32}$	$\frac{1}{32}$
$\frac{3}{64}$	$\frac{1}{16}$
$\frac{1}{16}$	$\frac{3}{32}$
$\frac{3}{32}$	$\frac{3}{16}$
$\frac{1}{8}$	$\frac{5}{16}$
$\frac{3}{16}$	$\frac{9}{16}$
$\frac{1}{4}$	1
$\frac{5}{16}$	$1\frac{5}{8}$
$\frac{3}{4}$	$2\frac{1}{2}$

In an entirely different category is the decorative type of post-forming laminate. This is the combination melamine-phenolic paper base material. It is necessary to use melamine resin on the surface of decorative material because of its heat resistance, abrasion resistance and color fastness. Unfortunately, from a post-forming standpoint, melamine is fundamentally a much more brittle thermosetting resin than phenolic. As a consequence, the minimum bending radii obtainable with this combination assembly are much larger than those obtainable with a 100 per cent phenolic assembly. With the normal decorative post-forming grades available, which are approximately $\frac{1}{16}$-inch thick, a $\frac{3}{4}$-inch radius can be formed when the decorative melamine surface is put in tension during the forming, i.e., an outside bend; a $\frac{3}{8}$-inch radius can be formed when the decorative melamine surface is put in compression, i.e., an inside bend.

From a paper of the same title presented at the Twenty-Second Annual Meeting of the American Society of Tool Engineers in Philadelphia, Pa., April, 1954.

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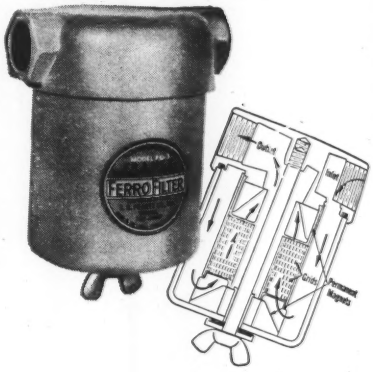

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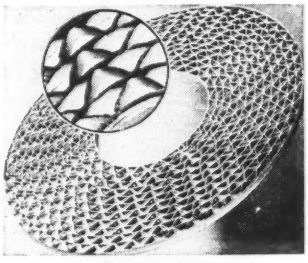

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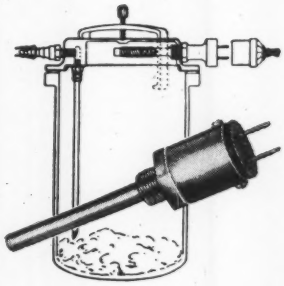

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BOX 1-P - WARSAW, INDIANA

MEN
OF MACHINES

Richard B. Holmes, general manager of Link-Belt Co., Philadelphia, has been elected president of the American Gear Manufacturers Association for the fiscal year 1954-1955. Mr. Holmes graduated from Purdue University with a B.S. degree in mechanical engineering. He has spent his entire business career with Link-Belt, serving in various capacities and assuming his present position in 1945. Mr. Holmes has been an active AGMA member for a number of years and has served as chairman of several committees, as a member of the executive committee and as treasurer and vice president. He is also a member of the American Society of Mechanical Engineers, the Metal Manufacturers Association and the National Metal Trades Association.

Richard B. Holmes

Formerly assistant to the company's vice president of engineering, **Frank W. Davis** has been named chief engineer of the Fort Worth Div. of Consolidated Vultee Aircraft Corp. In 1947 Mr. Davis joined the engineering staff of Con-

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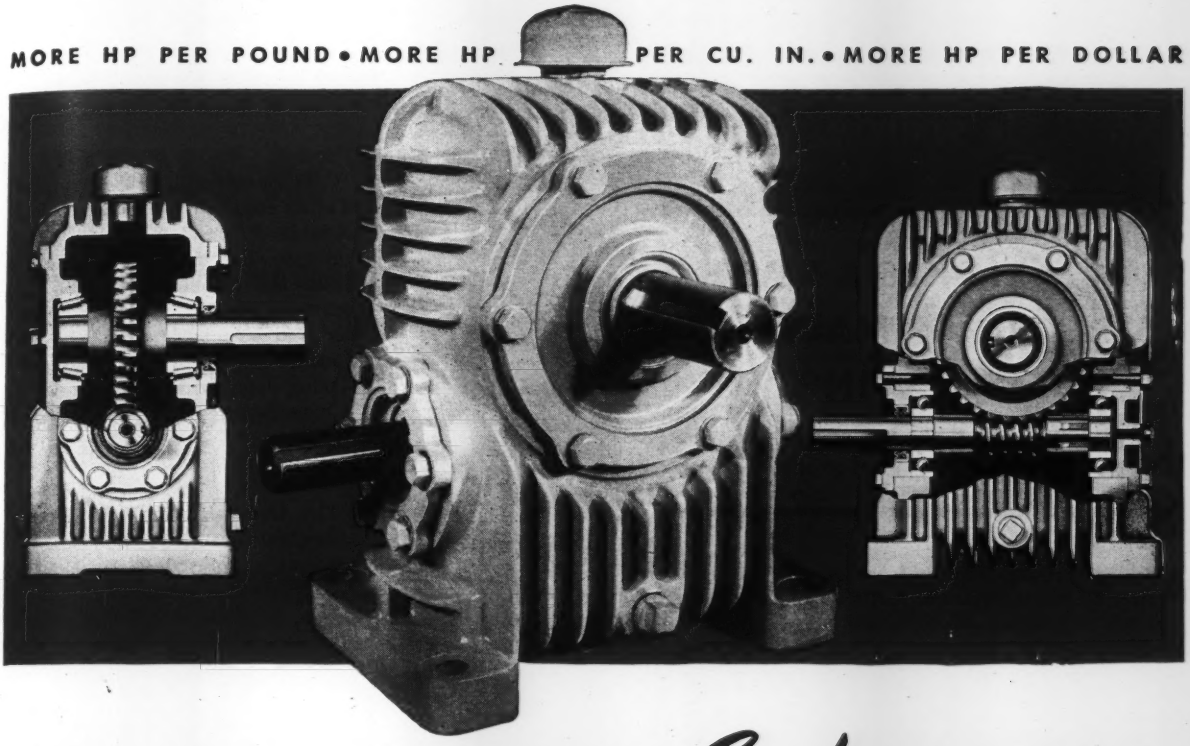

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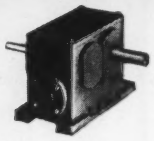

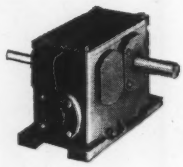

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MEMBER OF AGMA

Men of Machines

vair's San Diego Div., where he served as chief design engineer.

C. B. Campbell has been appointed chief engineer of the South Philadelphia, Pa., Steam Div. of Westinghouse Electric Corp. Having joined the company in 1919 as a technical apprentice, Mr. Campbell has held various supervisory positions in the steam division's engineering department and has served as consulting engineer for the division since 1952.

The General Machinery Div. of Allis-Chalmers Mfg. Co., Milwaukee, has appointed **R. C. Allen** director of mechanical engineering and **L. J. Linde** director of electrical engineering. Mr. Allen had been consulting engineer in the office of the director of engineering since 1951. He joined the company's steam turbine department in 1936, after serving in executive engineering capacities for various concerns including Westinghouse Electric Corp., A. O. Smith Corp. and Murray Iron Works Co. At Allis-Chalmers, he served as chief engineer, assistant manager, and manager and chief engineer of the steam turbine department until 1947, when he became manager and chief engineer of the turbopower development department. Mr. Allen is a member of the Amer-

R. C. Allen

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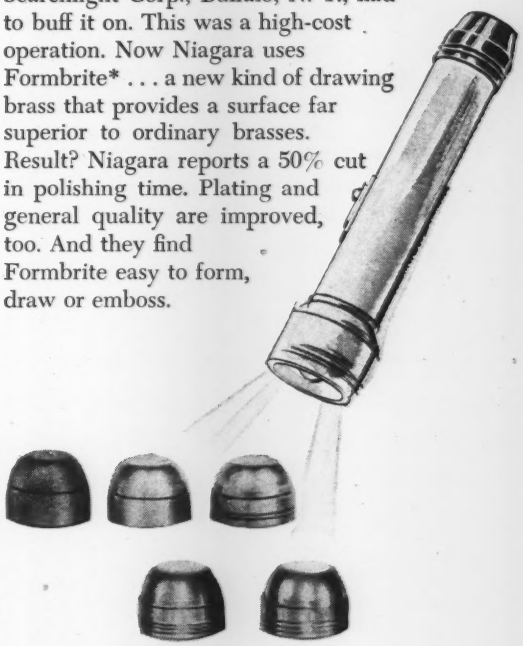

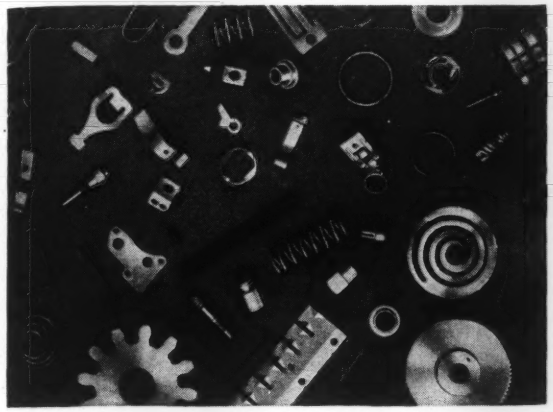

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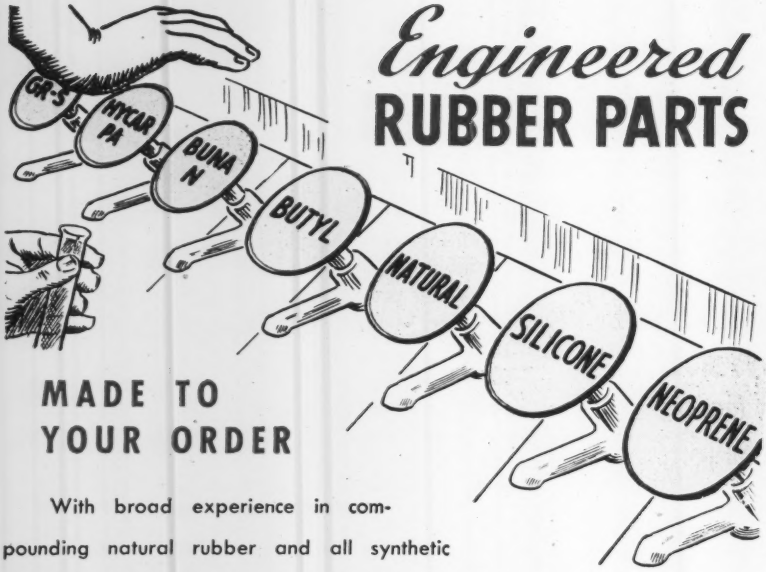

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Men of Machines

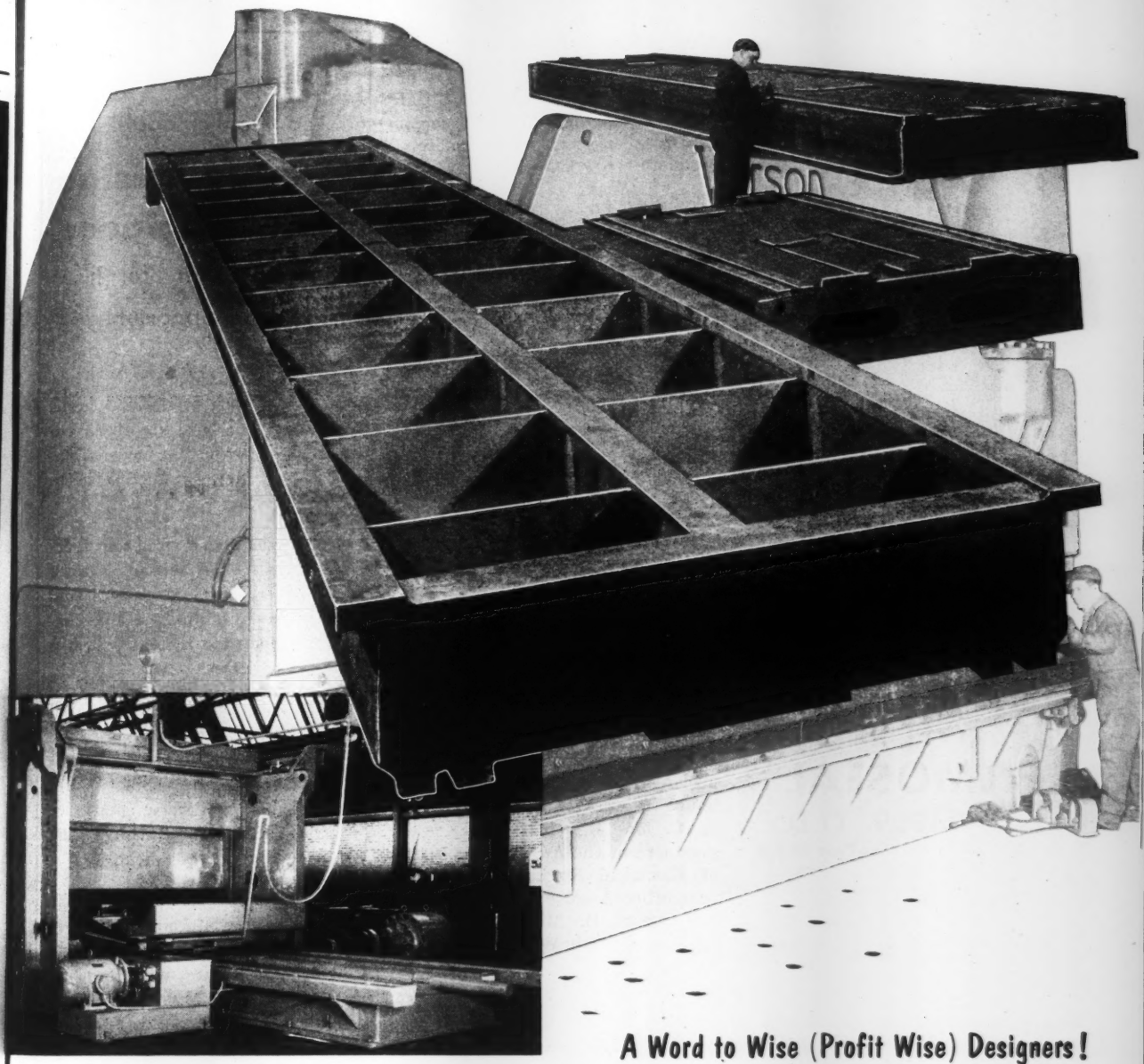
L. J. Linde

ican Society of Mechanical Engineers, the Society of Naval Architects and Marine Engineers, the American Society of Naval Engineers and the Engineers' Society of Milwaukee.

Mr. Linde served Allis-Chalmers as a consulting engineer before his appointment as assistant general manager and chief engineer of the Boston Works in 1951. Previously he was chief engineer for A. B. Chance Co. and was associated with the power circuit breaker division of General Electric Co. He is a member of the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the Electrical Engineers Institute of England and the International Conference on High Voltage Research of Paris, France.

Daystrom Instrument Div. of Daystrom Inc. at Archbald, Pa., has named **Nelson H. Mageoch** vice president. Mr. Mageoch has been director of engineering and research at the instrument plant since 1951.

The appointment of **Roy Witte** as chief mechanical engineer and **William F. Boylan** as chief electronic engineer has been announced by Magnecord Inc., Chicago. Mr. Witte joined the company in December 1953 as a project engineer. Mr. Boylan has been associated



A Word to Wise (Profit Wise) Designers!

Our 1,000 TON PRESS BRAKE Cuts Costs Whenever It's Used!

Shown above is the new and world's largest precision abrasive belt grinder—designed and built by Hill Acme of Cleveland, Ohio. The three weldments shown form the base for this machine. Bending played a large part in the forming of this base.

To what extent our Press Brake is used, depends largely upon the design engineer... This Brake will bend one inch plates up to 18 feet long. Also plates up to six inches thick in variable lengths depending upon bending detail. By using this Brake, we can show you record savings over conventional cutting and welding.

Couple these savings with our completely modern shop, under the guidance of top welding engineers, and you have a combination that is hard to beat for service, as well as price. Write now for further information.

Republic Structural Iron Works

Division of

THE CONSOLIDATED IRON-STEEL MFG. CO.

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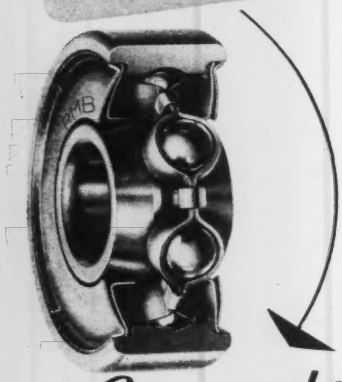

Miniature

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TYPE RF

FILMOSEAL

from 0.1969" O.D.

Smallest Sealed Retainer Type Radial Ball Bearing

An* RMB *First

This is a miniature bearing! It looks like a big bearing, doesn't it? That's because it has all the features of a big bearing, such as—

- Deep groove races
- Balanced two-piece or snap-type ball retainer
- Non-rubbing capillary oil seal
- Removable and replaceable dust shield
- Precision tolerances

RMB Type RF Filmoseal bearings (illustrated) are available in sizes from 0.1969" O.D.

Type RF now available in R2 size (ABEC-1, 3, 5) (⅛" bore—⅜" O.D.)

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A complete line of over 250 miniature and instrument bearings including radial and roller types available for prompt delivery. Experimental quantities from stock.

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Men of Machines

with Magnecord since 1950 as an electrical engineer and as senior electrical engineer on commercial production.

Waterbury Farrel Foundry & Machine Co., Waterbury, Conn., has appointed **George Backman** manager and chief engineer of the Rolling Mill and Mill Machinery Div. Mr. Backman joined the company in 1930 as an engineer in the press department, working on the design and development of presses and cartridge machinery. He was transferred to the Rolling Mill Machinery Div. in 1936.

H. G. Bauer has been appointed to the new post of vice president and general sales manager of De Laval Steam Turbine Co., Trenton, N. J. He previously served as vice president in charge of engineering and manager of the marine division.

Vice president in charge of engineering and research of Westinghouse Electric Corp., Pittsburgh, **A. C. Monteith** has been elected president of the American Institute of Electrical Engineers. He will take office August 1 and will serve for a year. Dr. Monteith has been associated with Westinghouse for 30 years, having joined the company as a student trainee and pro-

A. C. Monteith

Please show this to a highly capable

Product-Design Chief Engineer

who is ready for his lifetime opportunity

We are enlarging our line, and need a Chief Engineer who is competent to head up three important departments: General Engineering, New Product Development, Testing Laboratory.

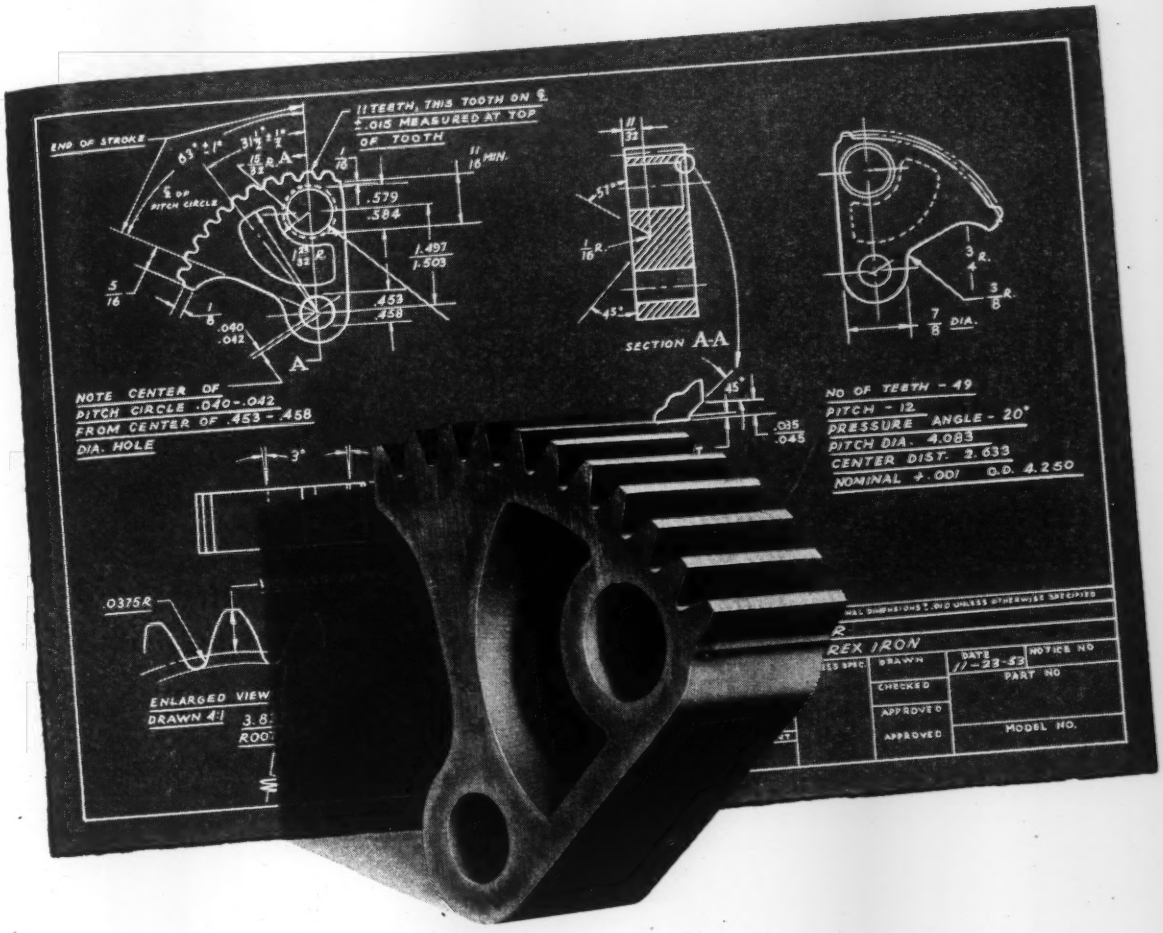
He must be a mechanical engineer with experience in electrical and metallurgical design problems, preferably of products such as electrical conductor fittings, which is one of our lines.

Experience in testing mechanical and electrical devices will be valuable, as one of his first duties will be supervising the equipment of a new laboratory being built for testing conductor fittings and other electrical equipment.

This opportunity is exceptional, for a man who can measure up to its requirements. Authority will be commensurate with responsibility. As Chief Engineer he will be a member of our top-management team, and as such will be compensated by a combination of base salary and executive bonus.

If you know someone who measures up to this opportunity, please have him write us giving complete information including age, education, and full details of experience. All replies will be held in strictest confidence. If qualified, a personal interview will be arranged either in the applicant's city or at our plant. Our employees know of this advertisement.

Box 847
MACHINE DESIGN
Cleveland 13, O.



COMPLEX PARTS ARE A CINCH FOR MORAINE POWDER METALLURGY

By conventional casting and machining methods, this part would be high in cost and would require extensive equipment investment. Through the use of metal powder techniques, it has been mass-produced with important over-all savings.

Note the construction details on the print in the background. Formerly many machining processes were necessary before this part was ready to be assembled into a complete, operating mechanism. Now it comes from a press complete in a single operation . . . another example of what can be accomplished through cooperative effort between customer and Moraine.

Moraine's experience with metal powder is contributing widely to modern industry. Many complex designs are resolved into practical, economical production jobs that improve performance and lower costs.

m

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DIVISION OF GENERAL MOTORS CORPORATION, DAYTON, OHIO

METAL POWDER PARTS

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Out of Your Picture
MECHANICS Roller Bearing UNIVERSAL JOINTS will give *your* trucks *more road time* and *less shop time* because MECHANICS JOINTS are specially designed with less parts and connections — for *easy assembly* and *servicing* — *smooth running balance* — *maximum strength* with *less weight* — and *long, trouble-free, safe operation.*
MECHANICS JOINTS can be serviced without disturbing other attachments or altering original propeller shaft balance. Let MECHANICS engineers give *your* trucks or heavy duty machines these competitive advantages.
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UNIVERSAL
JOINTS

gressing through various positions to the post he now holds. He received the Westinghouse Order of Merit in 1948. A fellow in the AIEE, Dr. Monteith is an honorary member of the American Society of Mechanical Engineers and a member of the American Society for Engineering Education, the Engineers Society of Western Pennsylvania and the Conference Internationale des Grands Reseaux Electriques.

Joseph P. Crosby, vice president and a director of LaPointe Machine Tool Co., Hudson, Mass., was elected president of the American Society of Tool Engineers for the coming year.

Evans T. Morton has been elected a vice president of Midwest Mfg. Corp., subsidiary of Admiral Corp. at Galesburg, Ill. A graduate of the University of Michigan, Mr. Morton spent two years on development work in the Norge refrigerator laboratory, then joined Stewart Warner Corp. as chief laboratory engineer. He became associated with Admiral in 1942 as a production engineer, was made design engineer in 1944 and later became chief engineer. When the company acquired Midwest Mfg. Corp. in 1950, he was appointed director of engineering of Admiral major appliances, a position he retains.

Evans T. Morton

To everyone this is a sign of peace

And to smart gear users this CINTI is a sign of *good* gears.

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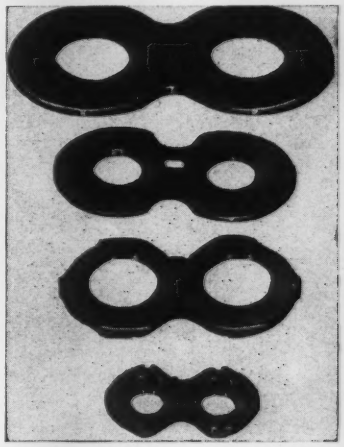
WEARING PARTS



Wear Plates—Promet #6

Sold only under a rigid guarantee of superior and satisfactory service or a refund of the purchase price upon return—the customer's opinion to be final.

Available in standard and special formulas developed to cope with specific or unusual conditions. Assure the best combination of physical properties, strength in tension and compression, hardness, and ability to sustain both static and dynamic loading.

Protect the shaft or other moving parts from injury, scoring, and seizing due to temporary interruption or failure of lubrication, and at the beginning and end of a run, when the speed of rotation is insufficient to maintain the oil film.

Will not powder under the most severe conditions of service. Available rough cast or machined to precisely controlled tolerances. They can be machined at surface speeds up to 875 lineal feet per minute.

Castings to your patterns—any size, shape or section—delivered as scheduled and specified. Pattern making, designing and machining when required.

Write today for free literature and service data sheets. Send blueprints, conditions of operation and other data for recommendations and quotations. You are invited to discuss your bearing problems with our metallurgists, engineers, and laboratory technicians.

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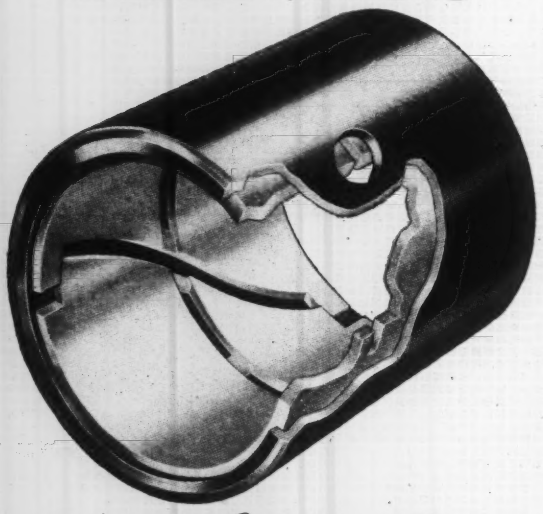

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*NYLINED Bearings have a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use.

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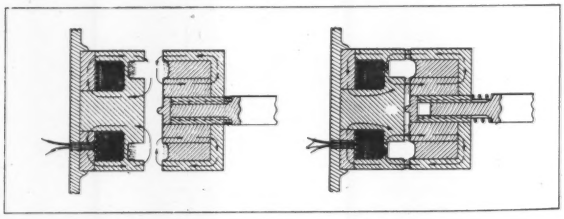
The Ball Bearing for Linear Motions

NOTEWORTHY

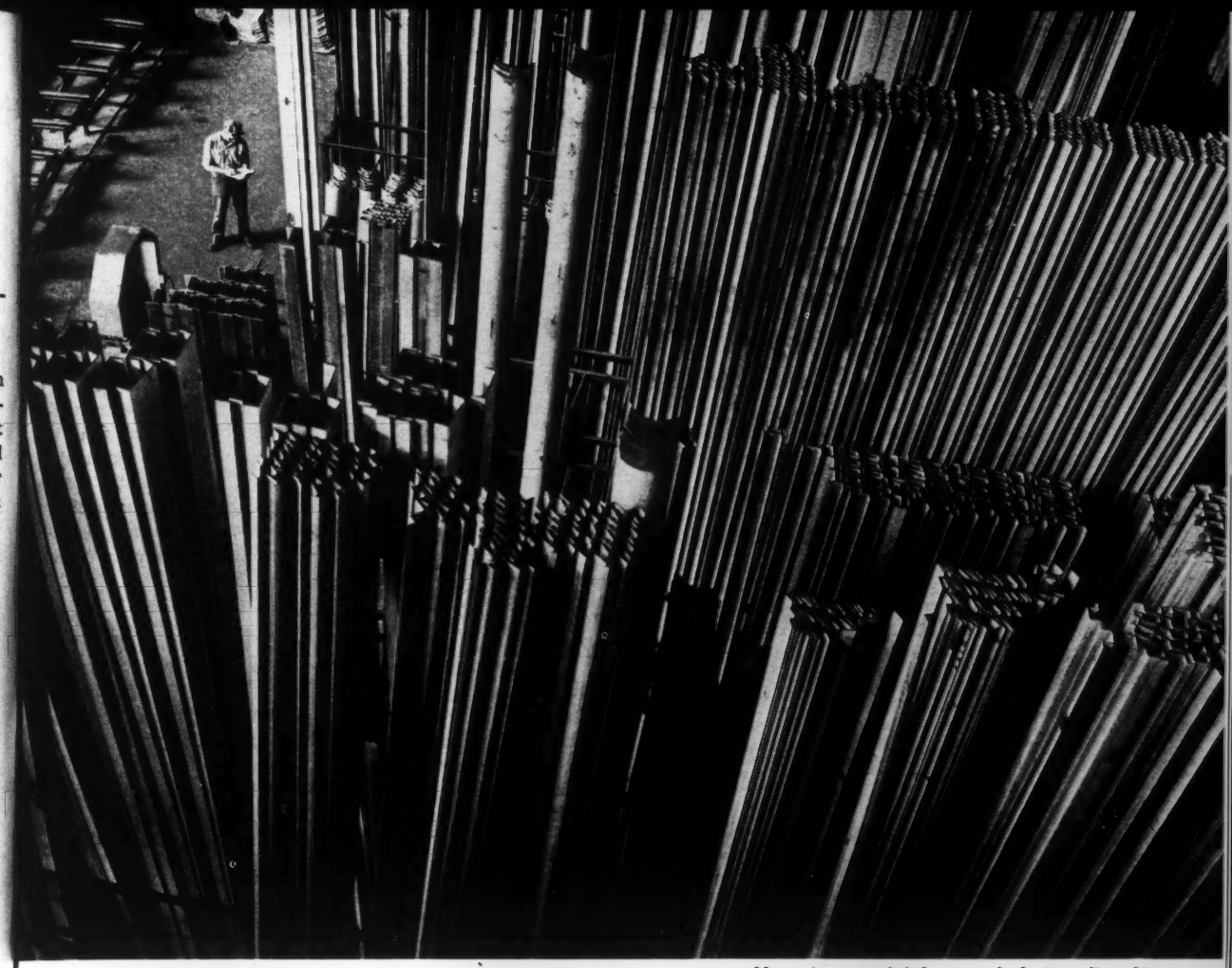
Patents

INTERMITTENT ROTARY MOTION for driven shafts is achieved with a combination drive mechanism designed by E. Wildhaber and described in patent 2,656,731. Combining a gear drive with a pin and slot drive, the mechanism converts uniform angular velocity into a cyclic motion in which the driven shaft accelerates gradually from dwell to maximum velocity, is rotated through a predetermined angle at this velocity, and then gradually decelerates to a dwell, remaining in the dwell position while the drive member rotates through a prescribed angle. The deceleration, dwell and acceleration motion sequence is produced by the pin and slot drive which is designed to pick up the load just as the partially-toothed drive gear disengages from the driven shaft. When the driven shaft enters the uniform velocity portion of the cycle, the gear drive re-engages and the pin and slot drive is disengaged. Assigned to the Gleason Works, the patent also describes a modified form of the mechanism for machine indexing applications.

FAIL-SAFE BRAKING of rotating members is obtained magnetically with a unit designed by K. M. Feiertag. Based on the principle of the magnetic-particle clutch, the design detailed in patent 2,656,026 employs two opposed magnetic fields, one generated by a set of permanent magnets and the other by electromagnets, to control braking action. Brake engagement is provided by the permanent magnets which act to solidify an iron particle mixture in the air gap between the stationary and rotating members. Brake



release is accomplished by energizing the electromagnets which produce a bucking magnetic flux to neutralize the particle mixture. Degree of braking effort can be varied through regulation of the current supplied to the electromagnets; complete power failure causes the brakes to lock in the engaged position. Also suitable for use as a clutch, the design offers application where driving connection between rotating members is required even though the power

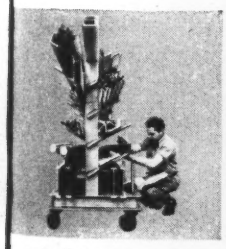


Magnesium extruded shapes ready for immediate shipment.

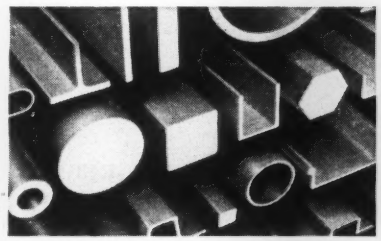
a new look at Magnesium!

NEW AVAILABILITY... SHAPES AND LENGTHS NEVER BEFORE EXTRUDED

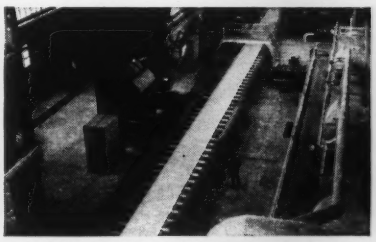
Designers and cost-conscious production men have found the answer to their problems in many applications with magnesium extrusions—now produced by new Dow facilities. Standard and special shapes, bars, rods and tubing—all are readily available in alloys which save weight, add strength, cut costs. Get information on magnesium from your nearest Dow sales office or write THE DOW CHEMICAL COMPANY, Midland, Michigan.



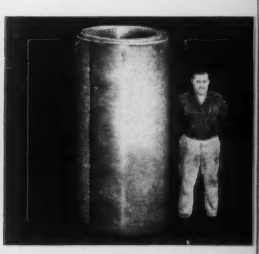
spector checking special ex-uded shapes offered in a wide ariety of alloys and sizes.



Magnesium bars, rods, shapes and tubing. Available in diameters or cross sections up to 10 inches.



World's first 84-inch magnesium coil mill now rolls sheet and plate in greater lengths and widths.



This coil of magnesium shee started through the 84-inch co mill as a one-ton rolling ingo

you can depend on DOW MAGNESIUM

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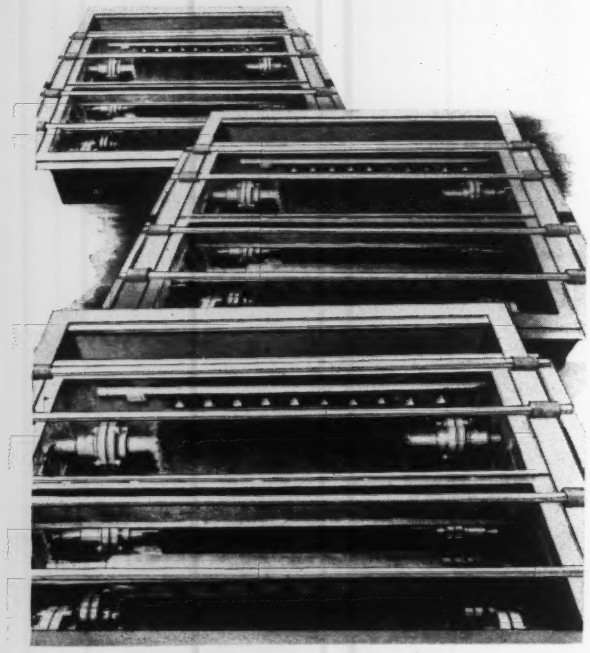

High quality finish and low maintenance costs are features of these Pittsburgh brushes used as original equipment by the W. S. Rockwell Co.

Want to Improve Original Equipment?

Here's the experience of one firm that did, the W. S. Rockwell Company, Fairfield, Conn., producers of a line of cleaning machines used on continuous strip annealing and pickling lines. A special problem existed in connection with these machines since the cold water rinse employed had a corrosive effect on most wire brushes.

Pittsburgh recommended four stainless steel wire brushes . . . operating in a stainless steel tank. The brushes proved to be the answer—providing fast, economical performance while resisting corrosion.

WRITE TODAY for your free copy of our new booklet that shows, through actual case histories, how Pittsburgh can help cut your brushing costs. Address: Pittsburgh Plate Glass Co., *Brush Division*, Dept, W-5, 3221 Frederick Ave., Baltimore 29, Md,

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Power Driven

BRUSHES

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PITTSBURGH PLATE GLASS COMPANY

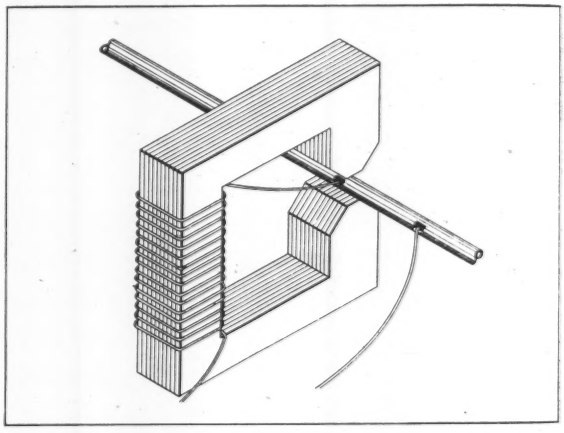
IN CANADA: CANADIAN PITTSBURGH INDUSTRIES LIMITED

Noteworthy Patents

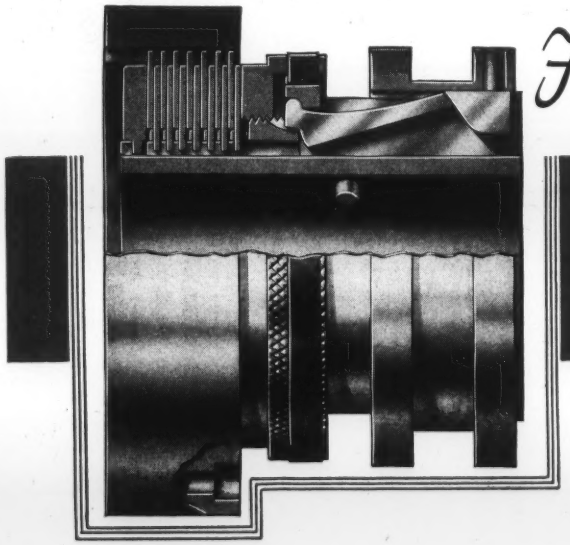
supply is interrupted. Assignee of the patent is General Electric Co.

ROTATIONAL SPEED MEASUREMENT of high-speed shafts is accomplished with a novel fluid pressure tachometer designed by H. E. Barrett, S. J. Hall, and W. C. Schaffer. Described in patent 2,657,699, the device uses the principle of the flyball governor to move a piston that controls the fluid pressure output of the device. Designed so that the pressure is proportional to the rotational speed of the shaft, the device can be utilized as a means of automatic speed control and is suitable for application with turbines or other similar types of high-speed rotating machinery. The three inventors have assigned their patent to the Curtiss-Wright Corp.

ELECTROMAGNETIC FLUID PUMP without moving parts is described in patent 2,655,107 assigned to the Atomic Energy Commission. Designed for use with electrically conductive fluids, the pump utilizes the force resulting from the interaction of an electric current passing through the fluid and an impressed magnetic field to force the fluid through a tubular pumping chamber. Electric current is supplied by two electrodes placed along the tubing. Optimum pumping action is obtained by placing the pole pieces of the magnet so that one electrode is in the middle of the magnetic field. Application of the device as a flowmeter is also discussed in the patent which has been assigned by N. H. Godbold.



STEPLESS SPEED REGULATION of electrically controlled clutches is obtained with a variable resistance governor covered in patent 2,657,323. Designed by R. L. Jaeschke, the governor utilizes a carbon pile arrangement to automatically control current flow to the clutch. Mounted on the rotating output clutch



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MAXITORQ *floating disc* CLUTCH

There are 2 basic types of Maxitorq clutches . . . Single and Double. Above is a cut-away view of the single type . . . the double is shown at right. Each is available in 8 capacities (wet or dry) from ¼ to 15 h.p. @ 100 r.p.m. And from 13 to 788 max. working torque ft. lbs. Pulley type, Ring type, or Cut-off Coupling Driving Cups are also available.

The Maxitorq automatic overload release clutch (up to 5 h.p.) is extremely useful for protection of machine and product against accidental overload in high speed production. Special bulletin on request.

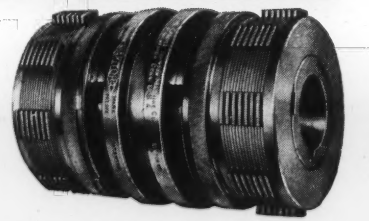
Send for Catalog No. MD-7

We hope you haven't minded turning this magazine around, but it was the only proper way to include the picture at the bottom. It clearly shows all parts of a single Maxitorq Clutch...and how easy it is to adjust it, take it apart, and assemble it...manually.

Each and every part contributes to smooth, positive, trouble-free clutch operation. The Separator Springs between each pair of inner discs keep them "floating" in neutral...preventing drag, abrasion, and heat. A Locking Plate locks all discs against the tension of the Separator Springs. The Adjusting Ring provides the means for obtaining the desired shifting pressure.

These are some of the reasons why we counted 69 machines, exhibited at the last Machine Tool Show, that were equipped with Maxitorq floating disc clutches. Send for our 50th Anniversary Catalog...and see how Maxitorq answers your problems for dependable power transmission.

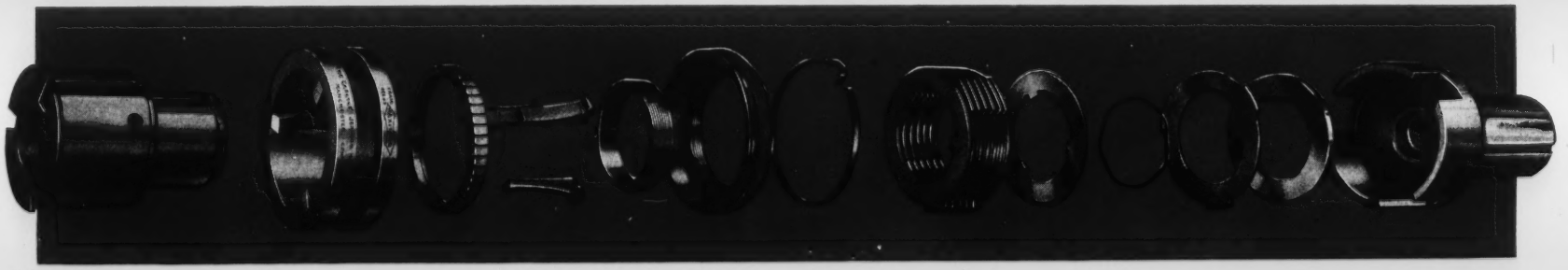
THE CARLYLE JOHNSON MACHINE CO.
MANCHESTER, CONNECTICUT



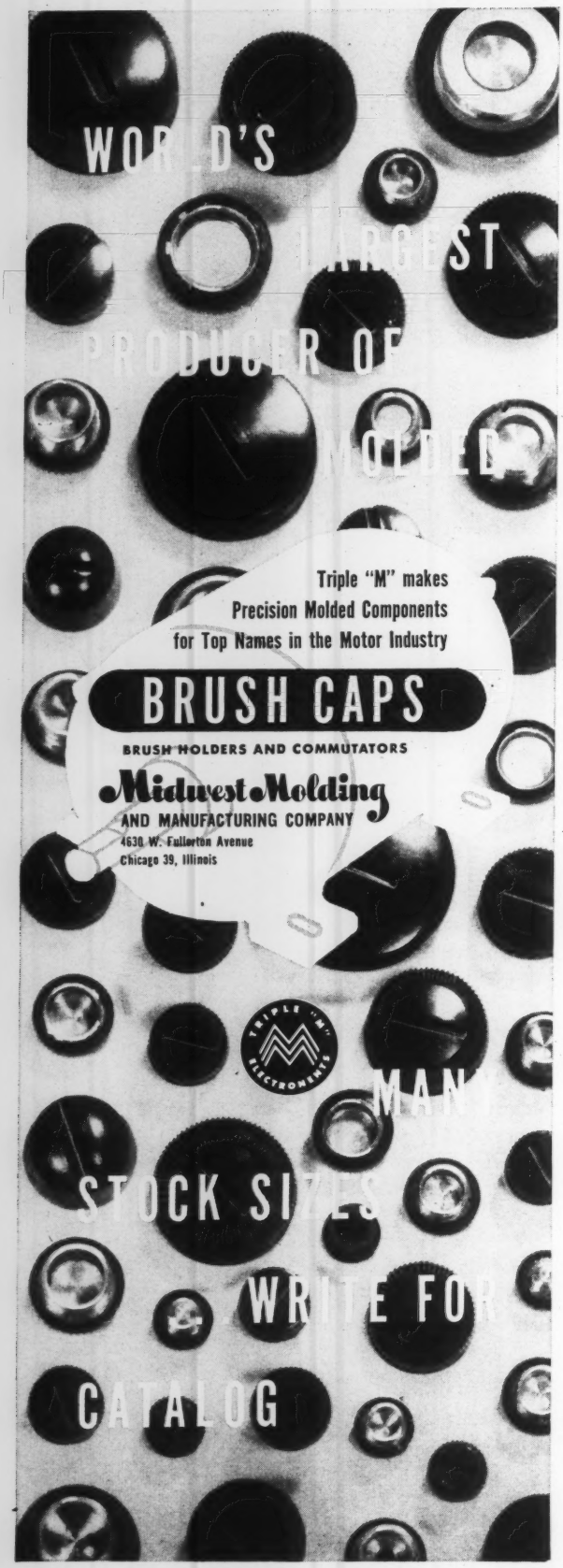
Compact, rugged construction and precise machining . . . flat, true surfaces on engaging faces of the discs . . . provide not only the exacting accuracy required in important industrial machines, but also long, profitable service life.

Our engineers will give you personal assistance for correct selection of the right clutch and installation for your specific requirement.

ALL ASSEMBLY, DISASSEMBLY AND ADJUSTMENTS ARE MANUAL. CLUTCHES SHIPPED ASSEMBLED ON THE BODY.

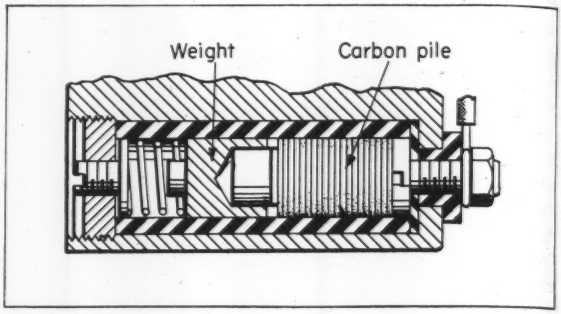


4CJ83



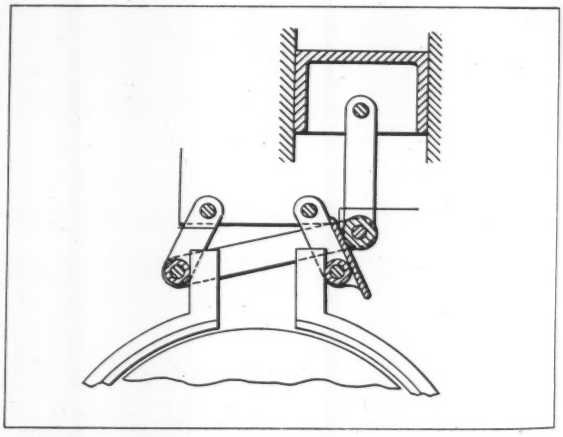
Noteworthy Patents

member, the governor has carbon disks which tend to separate or come together under the force of a moving weight controlled by centrifugal force and the action of a retaining spring. The resulting change



in resistance of the pile serves to control the current flow to the clutch or any other similar electrically controlled device. Offering high current capacity and freedom from arcing, the unit provides sensitive speed holding characteristics over a wide range. The patent has been assigned to Dynamatic Corp.

MECHANICAL BRAKING of rotating parts is accomplished with a novel clamping assembly described in patent 2,660,264. Based on the action of a roller against an inclined plane, the assembly tightens the brake band of a drum brake through two levers pivoted so their free ends pull the ears of the band together. Transmission of forces through the linkage



is controlled by a third lever which acts to synchronize the movements of the band tightening levers. Actuating force can be applied to the assembly from any angle; roller action assures that the clamping force will have no component except in the proper direction, thus minimizing uneven wear of the brake band. Inventor P. H. Richardson has assigned the patent to Paragon Gear Works.

Unretouched photo

To prove to yourself how tough Allen heat treated keys really are, slip a section of pipe over an Allen hex key that has already tightened a socket set screw to the maximum recommended. Twist the key around its axis a full 90° — IT STILL WON'T BREAK! When the Allenoy steel key finally does shear, the break will be smooth. No splinters, no jagged edges to cause injury.

• • •

For the toughest drive key made, get Allen Hex Keys, size-marked for convenience in all sizes above $\frac{1}{16}$".

When ordering through your local industrial distributor, specify genuine Allen Hex Keys.

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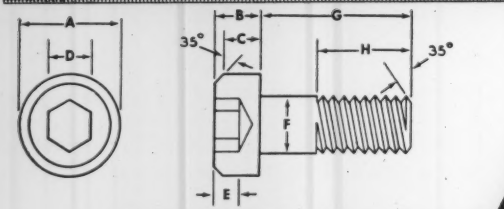

MAC-IT PARTS COMPANY							
MATERIAL SAE 4140 STEEL ALLOY - ROCKWELL							
FINISH CHROMIUM PLATING ON STEEL G.M 4251-							
TOLERANCE IN LENGTH THE TOLERANCE IN LENGTH							
A	B	C	D	E	F	G	H
3/8	244	229	185	127	248	5/8	3/8

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Mac-it socket-head screws, providing strength without bulk, give lighter weight, streamlining, and more secure fastening to equipment you design. Whether the design problem involves standard or special screws, Mac-it will add to the appearance, efficiency and performance of the equipment. Use Mac-it Fastener Engineering Service for all problems involving screws for any type application.

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The precision manufacture and quality control used in making Mac-it Screws provide users with high dimensional accuracy and uniformity. All Mac-it Screws in both coarse and fine threads are held to a class-3 fit. Mac-it maintains a Fastener Engineering Service for the design, development and production of screws for all types of applications.

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Hundreds of Mac-it distributors from coast to coast are ready to render immediate service in supplying your requirements for standard or special screw products.

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Contact your nearest Mac-it distributor or the Home Office, Cleveland, Ohio, for the Mac-it Catalog No. 49 which contains full technical data.

New Machines

Air Conditioning

Dust Collector: Sterilshield space cleaner removes dust, smoke, pollen and bacteria from the air. It utilizes a 1000 cfm capacity electrostatic air cleaner, with its associated power supply. A propeller fan drives air through the unit horizontally from one end to the other. Mounted on casters for portability, the unit is 33 in. long, 32 in. high and 21 in. wide. Dust collector cell is easily removed from its compartment for cleaning. *Baker Co., Maplewood, Me.*

Small Cooling Tower: Model JACT, with 15-ton capacity, is largest of a line of five cooling towers designed for use in a small home air conditioning system or a cooling system for a group of offices. Compact unit offers several possible locations for air outlets. Galvanized after fabrication, it is suitable for indoor or outdoor installation and has a blower and fan system to provide constant capacity in either type of location. Cooler conserves 95 per cent of the water used when no tower is installed. *Acme Industries Inc., Jackson, Mich.*

Ventilator Fan: Axial flow design ventilator delivers 300 cfm of air. Intake scroll measures 11 in. in diameter; housing is 5½ in. high. Horizontal installation is possible in restricted joist space, and because of straight-through air flow of axial design, elbows are eliminated in duct work for vertical installation. Mounting bars extend from housing. Unit incorporates three air-foil shaped blades or runners mounted on a hub of relatively large diameter, which concentrates the work on the air to the outer part of the runners where the greatest pressure is produced. Runner assembly is mounted in a streamlined venturi-shaped housing which increases the velocity of air through the runners. *Trade-Wind Motorfans Inc., Los Angeles, Calif.*

Materials Handling

Electric Fork Truck: Characteristics of 5000-lb capacity model F-30T5 electric powered fork truck include contactor controls, worm drive, caster trail axle, rocker arm tilt, front-wheel drive, rear-wheel steer, tilting and telescoping mast, center control. Travel speed is 5½ mph with full load, 6 mph without load. Lifting speed is 25 fpm with full load, 42 fpm without load. Lowering speed is 45 fpm with full load, 36 fpm without load. Hoist and tilt mechanisms are hydraulically operated. *Elwell-Parker Electric Co., Cleveland, O.*

Reciprocating Conveyor: Designed to feed a constant volume of any dry or moist material from an overhead bin, new reciprocating conveyor operates from plant air supply, with electricity required only to operate a solenoid air valve. Units of various capa-

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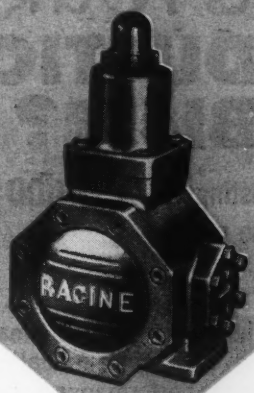

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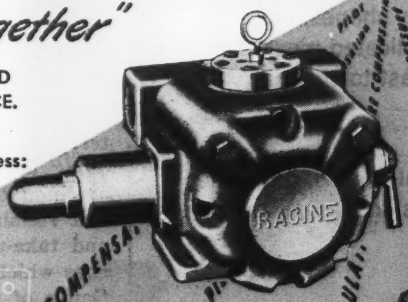

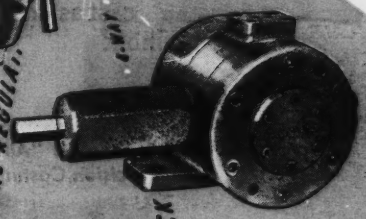

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cities are available, and each conveyor is easily adjustable from maximum capacity to zero. Operation is not affected by lumps or variations in the consistency of the material handled. *Hydro-Blast Corp., Chicago, Ill.*

Electric Hoist: Made in two and three-ton capacities, class BB Lo-Hed electric hoist has welded steel chassis. It also has heat-treated alloy steel, straight-line, three-reduction spur gears; automatic heavy-duty lowering brake; heavy-duty hoist and crane type motor; single-speed pushbutton control, 110-v at the pushbutton; completely shrouded, all steel safety type bottom block; ball bearing sheaves; antifriction thrust bearing to carry hook. Drum is located on one side of the hook, the motor on the other side. *American Engineering Co., Philadelphia, Pa.*

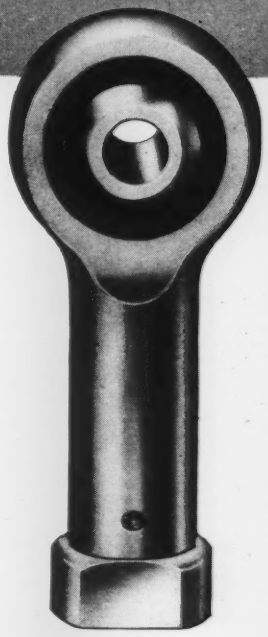
Roller Conveyor: LR Live Roller conveyor is used for long-distance horizontal handling of materials that may vary widely in shape, size and weight. Articles can be stopped at any point for operations such as inspection, labeling or weighing, without interfering with the flow of goods at any other point along the line. Carrier rollers and pressure rollers are mounted in the same frame, with a motor-driven belt running between the two sets of rollers. Drive and take-up units are separate self-contained packages which can be mounted at any point on the under flange of the conveyor frame. Conveyor is made up of 10-ft sections that can be combined to give unit lengths up to 150 ft. Eight frame widths range from 15 to 39 in. Individual roller capacity is 250 lb under normal duty conditions with distributed load capacity of the unit subject to motor size, belt speed and roller spacings. Standard speed is 80 fpm; speeds from 60 to 200 fpm are available. *Rapids-Standard Co. Inc., Grand Rapids, Mich.*

Metalworking

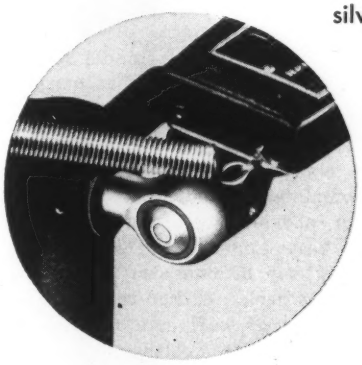
Surface Grinder: Redesigned 14-in. hydraulic vertical surface grinder, designated Model D, is available in either 14 x 36-in. or 14 x 60-in. size with solid ring wheel or 17 x 36-in. or 17 x 60-in. size with segmental wheel. Increased length and depth of heavily ribbed bed give greater support to table and column. Wider wheel headways, together with increased column bearing length, provide spindle head with additional support. Spindle is heavier and more rigid, and the wheel flange is an integral part of the spindle. Table speeds are infinitely variable and uniform from 2 to 100 fpm. Table traverse is controlled by two hydraulic cylinders; speed is controlled by metering the oil in the return lines. *Pratt & Whitney Div., Niles-Bement-Pond Co., West Hartford, Conn.*

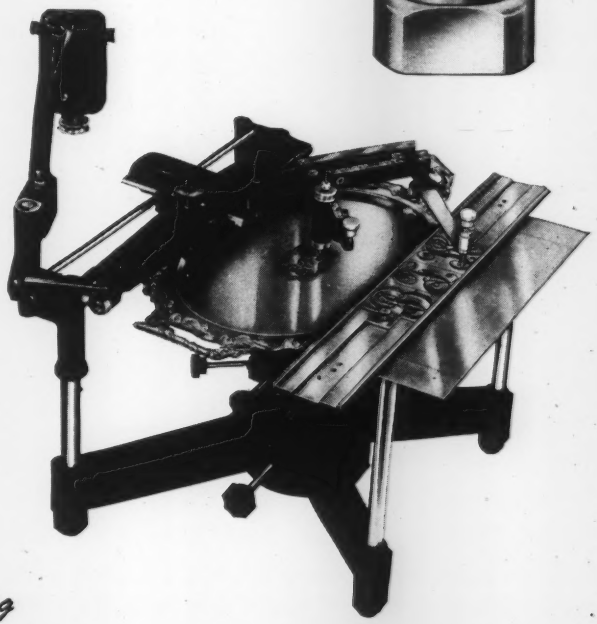
Horizontal Gear Shaver: Red Ring model GCJ-36 finishes teeth on spur and helical gears up to 36-in. pitch diameter having shafts up to 142 in. long, finishes gears up to 2 diametral pitch having face widths up to 36 in. and crowns tooth surfaces on spur and helical gears up to 12 in. wide having shafts up to 62 in. long. Machine is equipped with a power-

HEIM *Unibal* ROD ENDS



The New Hermes Engraving Machine Corp. of New York, world's largest manufacturer of precision engraving machines for the jewelry trade and also for industrial use, utilizes a pair of Heim Rod Ends to insure smooth and dependable functioning of the engraving arm. The compactly designed Engravographs are noted for their simplicity of operation in the quality engraving of watches, jewelry, and silverware as well as of dials, nameplates, signs and instrument panels.





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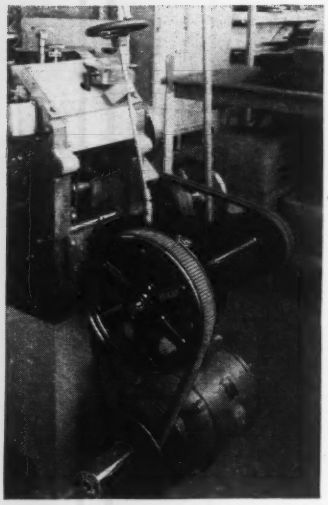

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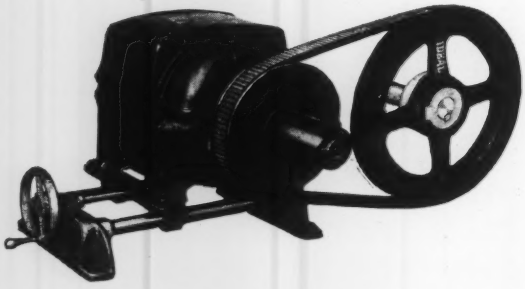

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New Machines

driven headstock and a center tailstock, each mounted on base extensions and traversed by rack and pinion for positioning. Gear and shaft assemblies can be mounted in the machine on the shaft centers, or the machine can be equipped with a flexible type work driver which permits shaving of gear and shaft assemblies while rotating on the journal on which they will run in the equipment drive. *National Broach & Machine Co., Detroit, Mich.*

Profile Milling Machine: Model No. 50M Aeroframe machine mills and profiles irregularly shaped, complicated precision parts. Speed range of 125 to 4600 rpm permits machining of any material. Spindle has a No. 50 standard taper; machine is equipped with a two-speed vertical motor. Cross rail and bed have replaceable hardened steel ways with endless belts for protection from chips. Table and upper carriage carrying the spindle are mounted on roller bearings. Spindle bearings are automatically lubricated; table bearings have one-shot lubrication. Adjustable stops are provided for the table, upper carriage carrying the spindle and for depth control of the spindle. Distance between the centerline of spindle and follow-up pin is also adjustable. *Morey Machinery Co. Inc., New York, N. Y.*

Grinding and Polishing Machines: Four models of German-made contact grinding and polishing machines are completely integrated, double-end, pedestal types for abrasive belt contact grinding and polishing. All have approximate 18-in. belt adjustment, permitting use of one size belt with various diameter contact wheels. Either two belts, or a belt and grinding wheel or buff can be employed. Machines are equipped with positive belt tracking devices and spring-loaded belt tensioning and also have special belt attachments that can be easily positioned vertically and swiveled to horizontal. Machines are powered by 1.15, 3.5 and 7-hp motors and have corresponding belt speeds of 7000, 6300 and 7400 sfpm. *Curtis Machine Corp., Jamestown, N. Y.*

Precision Metal Cutter: Cavitron machine, for machining hard and brittle materials, can accurately produce 0.012-in. diameter holes or slots of that width. It will sink blind, through, tapered or curved holes of various desired shapes and depths; will engrave or type matrix dies and cut keyway and oil holes. Machine uses soft steel tool for cutting either ferrous or nonferrous materials, including those which are nonmagnetic and nonconductors of electricity. Operation is accomplished by use of an ultrasonic tool head vibrating from 18,000 to 30,000 cycles per second while a pump provides a continuous flow of abrasive grit in solution over work surface. Fine finishes are obtained without local heating or electrical burning of work or chemical or physical change in the workpiece. *Sheffield Corp., Dayton, O.*

Tube and Bar Straightener: Model 2MKTC guideless seven-roll straightening machine is designed for accurate, end-to-end straightening of 1¼ to 3¾-in. OD tubes and 1¼ to 3-in. diameter bars at high production speeds. A three-roll cluster, consisting of a

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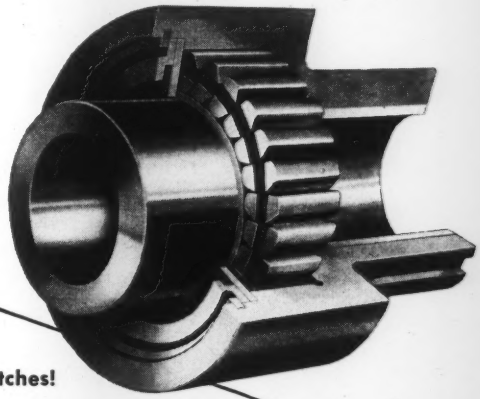

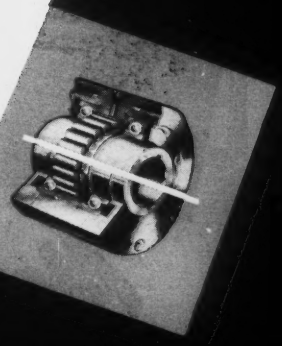

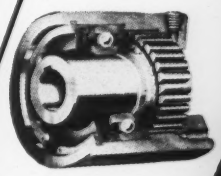

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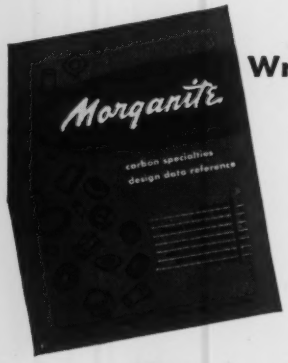

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large driven roll with two opposed idler rolls, is located at both the entry and delivery ends of the machine. Rolls are positioned at approximately 120 deg to each other. Between the clusters, at the center of the pass line, is an unopposed pressure roll. This arrangement provides guideless straightening of both ferrous and nonferrous materials. Machine has automatic roll angle adjustments, with coordinated angling of all rolls, and power-operated adjusting screws. Adjustment for different size tubes or bars takes less than 2 minutes. *Sutton Engineering Co., Bellefonte, Pa.*

Processing

Cabinet Drawer Oven: Model HBD oven, with 24 drawers, is adapted to preheating and stress relief of small parts, for processing nylon powders and for other processing from 100 to 850 F. Special drawer construction, which closes opening in cabinet when drawer is pulled out, permits insertion or removal of the contents of one drawer while keeping temperature at maximum required in remainder of oven. Other characteristics include high-volume adjustable air flow, high and low heat switch for close control and quick recovery, Inconel-sheathed heating elements, accurate indicating temperature control, manual interlock for purge period operation of blower without heat, electrical interlock for turning off heat in case of blower motor failure, adjustable positive exhaust and intake, and belt-driven fan. Drawers are 2 in. high, 12 in. wide, 26 in. deep; cabinet is 34 in. wide, 28 in. deep, 54 in. high. *Grieve-Hendry Co. Inc., Chicago, Ill.*

Vacuum Dryer: Conaform vacuum dryer provides fast heat transfer to entire batch of temperature-sensitive and easily oxidizable materials. It is a rotating unit of double conical construction which allows the surface layers of materials to constantly fall downward toward the cone during rotation. Since no portion of the dryer is perpendicular to the axis, the cascade pattern changes constantly so no groups of particles take parallel paths. Particles are constantly deflected from the cone walls to the center of the batch. Condensers can be applied and speed variation can also be included, allowing the unit to serve as a blender of a variety of materials prior to drying. *Patterson Foundry and Machine Co., East Liverpool, O.*

Resin Processor and Dispenser: Used in laminating; mat molding; matched die molding; plastic tooling; adhesives and sealers; potting, casting, embedment; protective, decorative and sealant coatings; and thermosetting extrusion, equipment automatically performs the functions of de-aeration, proportioning of resin and hardener components, mixing and meter dispensing. It processes polyesters, epoxies, allyl resins, furans, modified phenolics and polysulfide liquid polymers. Flow of material through the equipment is determined by the demand for the completed mix. De-aeration is performed by a film evaporation technique. Mixing is conducted by an

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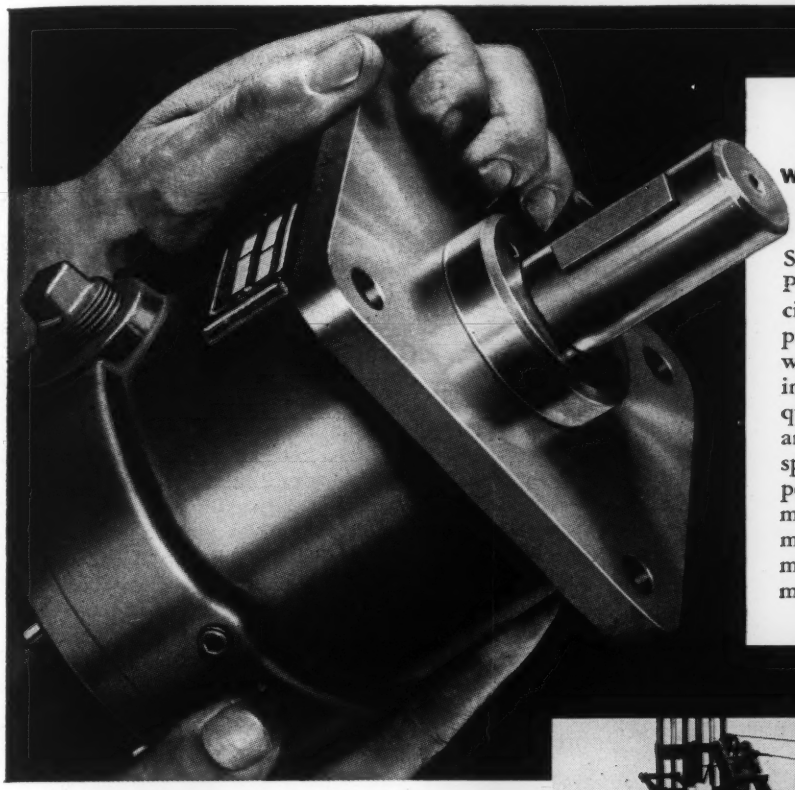

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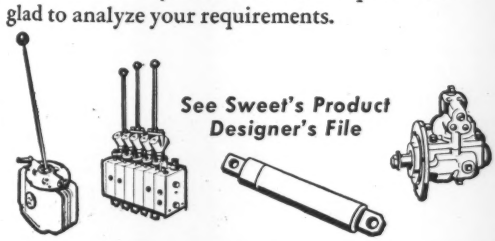

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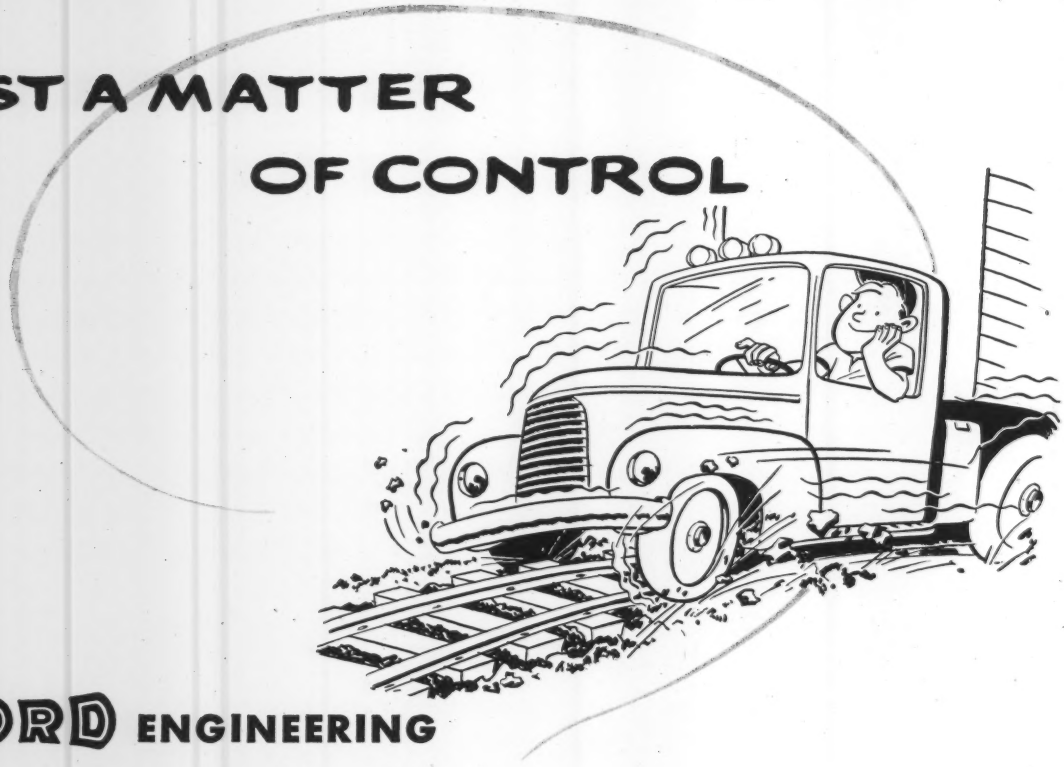

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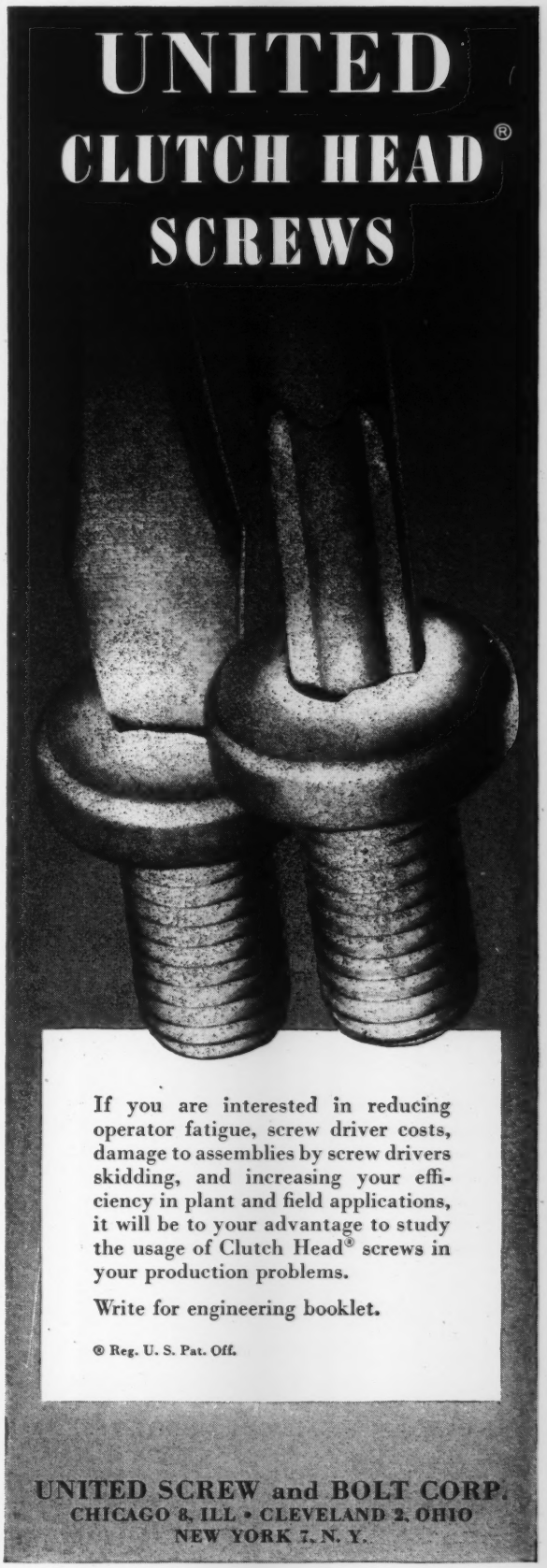
agitation-homogenization method. A reciprocating pump meters the finished mix. Pressure of 5 to 150 psi is required for conveyance of materials through the system, and a vacuum of 30 in. is used for deaeration. Processing temperatures of 10 to 350 F can be employed. All models are suitable for continuous or intermittent production. *Applied Engineering Associates, Brooklyn, N. Y.*

Air-Flow Drying Tunnel: Offered in kit form, two models of drying tunnels provide the component parts required to construct a tunnel with a 36-in. wide belt. One model has a hood length of 46 in., distance between belt centers of 84 in. and contains three radiant heaters rated at 2.5 kw each. Second model has a 70-in. hood, 108-in. belt length and six heaters of 2.5-kw rating. With each model, belt speeds from 5.6 to 23.4 fpm can be obtained, and intensity of the all-metal heaters can be varied from 4 to 100 per cent of their capacity. *Edwin L. Wiegand Co., Pittsburgh, Pa.*

Ball Bearing Washing Machine: Consisting of a cabinet, spray system, pumps, solution tank, rotating cones and filtering system, model RT washing machine is of the batch type with loading and unloading at the same location. Washing and rinsing operations are performed at the same time inside the cabinet using the same spray system. Cones with removable extension spindles hold bearings inside the cabinet. Inner races of the bearings rotate 360 deg in one direction and then 360 deg in the opposite direction, while the outer race is held in a fixed position. Machine has capacity of 500 bearings per day. *Equipment Div., Magnus Chemical Co. Inc., Garwood, N. J.*

Testing and Inspection

Hot-Cold Testing Unit: Testing chamber automatically cycles parts through alternate hot and cold temperatures. Temperature as low as −120 F is produced first, then temperature is raised to as high as 200 F. Cycle can be repeated as many as 100 times. Holding time at high and low levels is variable with a dual-set timer which determines half-cycle time anywhere between 0 and 120 minutes. Chamber is 30 in. long, 11 in. wide and 16 in. deep. *Cincinnati Sub-Zero Products Co., Cicinnati, O.*

Automatic Impact Tester: For determining the breaking point of gear teeth and studying the dynamic properties of parts subject to shock, progressive and repeat impact testing machine automatically raises and drops a hammer of known weight on the test specimen from progressively higher points until specimen breaks. After each stroke, the hammer is picked up on the rebound by a motor driven chain and raised to the next dropping point. Height of fall is increased by 1-in. increments. Machine can also be set to deliver the impact repeatedly from any desired height between 6 in. and 10 ft. Specimen holder adjusts to accommodate materials up to 24 in. high. *Tinius Olsen Testing Machine Co., Willow Grove, Pa.*